PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

We Should Know More About Steel

"To the winner belong the spoils." This applies not only to warfare but also to business and economic relationships. When this war is over there will be a tremendous battle to capture markets and far out in the forefront of this contest will be the competition of materials. With aluminum at ten cents a pound, it is only fifteen cents now, with plastics available at lower prices as the result of greater mass production, with low-priced synthetic rubber, resin bonded veneers, and glass for mechanical parts all seeking to maintain and to develop new fields of use, there will be "battles royal" to induce the design engineer to use this or that material.

When that situation arises there will also be a controlling factor that will largely determine which material the design engineer will use. That factor will be the design efficiency of the material. It is a factor which is important today but after the wholesale destruction of war ceases, the efficiency with which a material can be used will be the prime consideration.

With the world impoverished (even the richest nation will be poor) and facing a tremendous job of rebuilding and rehabilitating, circumstances and competition will compel that everything be done at maximum efficiency. That which is inefficient will be avoided. This will apply to all activities including design, production, promotion, sales and services. By that token, the material which in the mind of the engineer is most "efficient" with respect to meeting service requirements, economy of fabrication and assembly and total cost, will be the material to use.

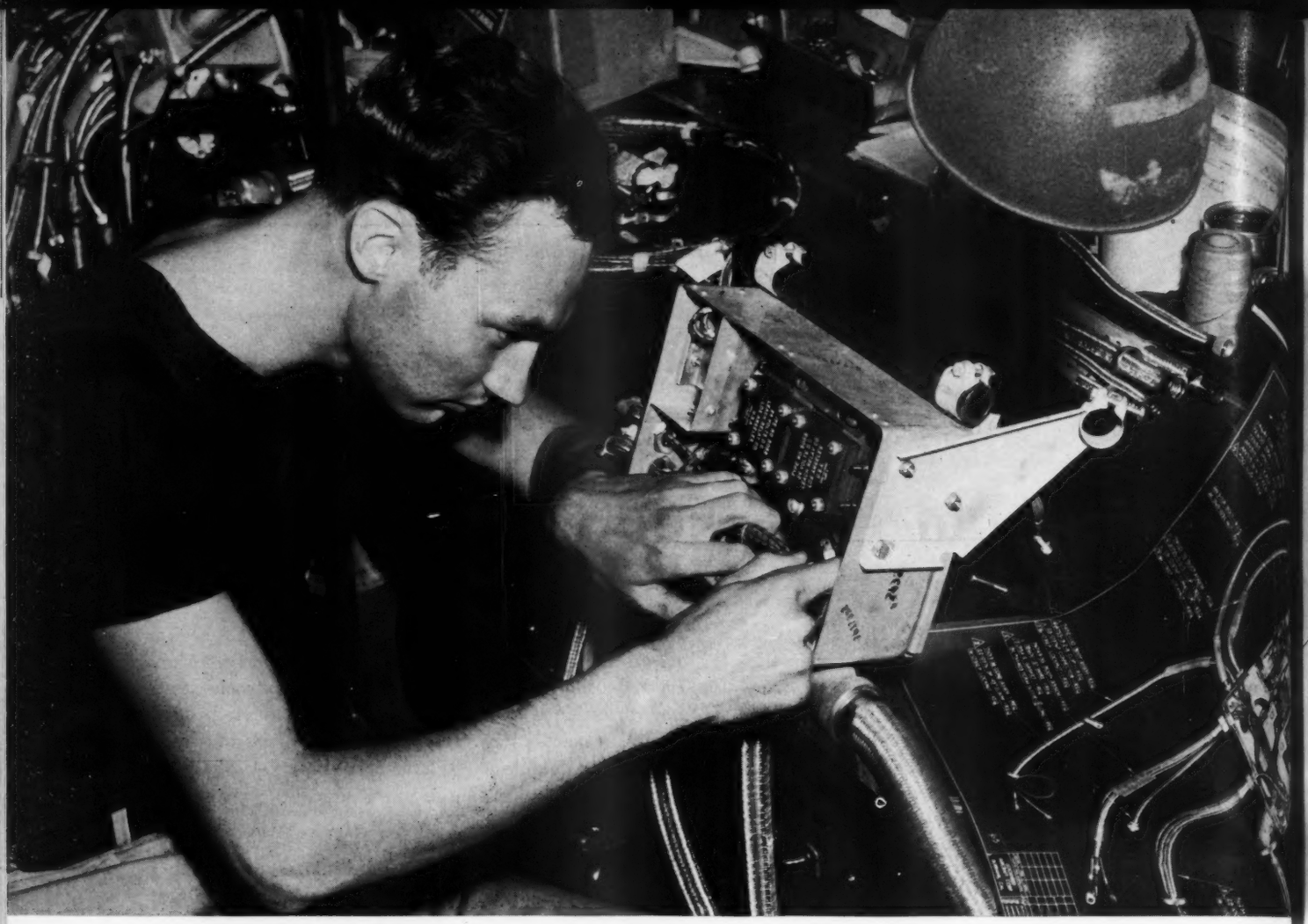
Fortunately for the design engineers, with only a few glaring exceptions the producers of materials have eagerly sought to find out how to use the materials. This information has been broadcast as it has been uncovered. Perhaps the leader has been the Aluminum Company of America. At great cost, the research laboratories of that company have developed design formulas and by extensive tests have determined the constants and other factors to be used in design calculations. The physical properties of aluminum and aluminum alloys have been found by exhaustive tests. Details concerning manufacturing processes have also been established.

Much the same might be said about many other materials including plastics, synthetic rubber, and natural rubber. But it cannot be said of steel, the oldest and most widely used material of construction.

Perhaps the steel industry has been negligent with reference to technological developments in the use of steel and the development of design data, merely because it is the oldest of these industries. When steel was in its period of rapid growth, the science of engineering design was almost non-existant. But be that as it may, today there is the American Iron and Steel Institute. In the sum total, the steel industry has money to spend. Designers should be told how to use steel efficiently.

It takes time to organize, to conduct tests, to correlate data, to establish design constants and to develop design procedures and production techniques. But not until this has been done, can the steel industry tell the design and production engineers "How to Use Steel Most Efficiently." Unless such a job is done, the present switches to plastics, glass, rubber, and other materials will in many cases prove to be permanent. Meanwhile aluminum and perhaps some other metals will make further inroads into the fields of use that once were considered the domain of steel.

Naturally, the designer prefers that material about which he knows most and can use most efficiently.



WIRING FOR AIRCRAFT

Electrical Assembly Designs That Speed Production

LESTER C. JONES
Engineer, Lockheed Aircraft Corporation

AIRPLANES of a single model today are being built by the hundreds, and in not a few instances by the thousands. The call for mass production of airplanes has given rise to modern assembly lines similar to those in the automotive industry. The number of planes on order does not compare in any respect with the amount of automobiles that are being produced, therefore, it is not likely that airplane assembly lines will be as detailed as are automobile lines.

Studies have shown that in order to keep the assembly line moving in an uninterrupted flow, operations in the final assembly department should be as few as possible. At the same time, the number of men engaged in final assembly should be small. Final assembly is not a fabrication department, nor should it be a sub-assembly department. Its function should be that of installing complete, component assemblies that have been delivered ready for installation from the various sub-assembly lines.

When insufficient thought is given to the practical application of the design, a "bottleneck" is likely to exist in regard to electrical installations. When electrical lines are not broken in the proper places to facilitate completion of bench assembly units some assemblies may have to be completed in the final assembly department or sometimes on the airplane, thereby causing unnecessary congestion and consequent delay in the completion of the airplane. To avoid conditions of this kind, design engineers should constantly keep in mind the production problems that are inherent in their designs. In other words, they should "design for production."

The breakdown of the electrical parts of the airplane should be handled like that of any other portion. Drawings should be made of all details and subassemblies even for simple assemblies which may consist of only a plug with a few wires soldered to it, as well as those like the one shown in Fig. 1 which may be so complex that they demand

more than one operation. It is important, of course, that sub-assemblies should be complete in themselves; that is to say, it should be possible for only one man to work on the assembly at a time.

If production warrants, an orderly assembly may be built to accommodate a small assembly of a major assembly. Sub-assemblies may then flow into a major assembly line. An example of a major assembly is shown in Fig. 1, which is a junction box having six flexible conduit assemblies with a cord plug or cord receptacle at the extremity farthest from the box. From each cord plug comes one or more wires which, when not routed elsewhere, terminate at a panel in the box. Each flexible conduit with its plug or receptacle and wires make up the complete sub-assembly. All six sub-assemblies when wired into the junction box constitute a major assembly; that is, if the assembly is then ready for installation. If, however, it in turn gets wired or assembled to a still larger unit, it then becomes a sub-assembly.

Many departments are affected by the design of electrical sub-assemblies. Those most concerned in the order of their importance are the shop, the stockroom, the maintenance or service departments, and the engineering department.

For the sake of economy in labor costs it is important to keep in the shop as much work as is possible in the sub-assemblies for it has been determined that 40 cents spent in labor in this department will be equivalent to $1.50 spent in the final assembly department.

For the benefit of the shop, "ease of assembly" should be kept constantly in mind; hence there are many details that must be studied by the design engineer before releasing production-assembly drawings to the shop.

Pictures or photographs that supplement drawings enable the men in the shop to visualize the parts better than third-angled projection drawings do. Full-sized images of the assembly reproduced on a blueprint for shop use promote "ease of assembly." Remembering the remark attributed to Confucius that "One picture is worth a thousands words," the designer should strive to utilize the advantage which pictures possess over words to the fullest extent, both in the use of assembly drawings and installation drawings. Since large blueprints are difficult to handle in the factory, smaller drawings should be used wherever practical.

There are times when it is possible to design large assemblies, however, they may not be practical because of difficulties which may arise in stocking the parts. An assembly should be designed

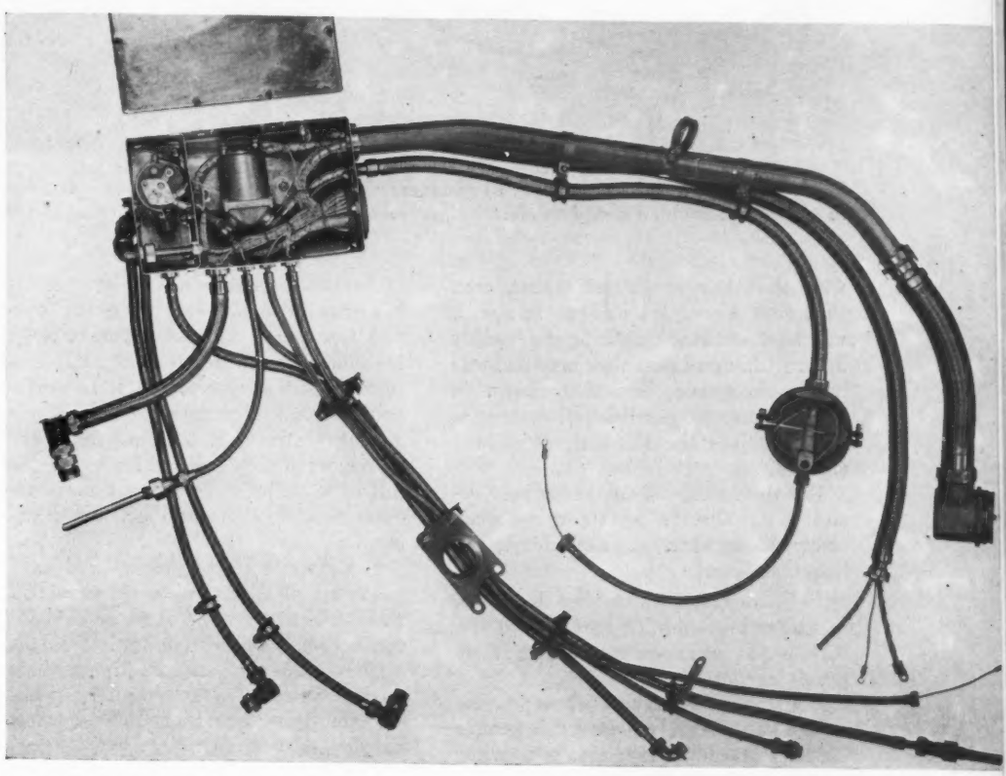
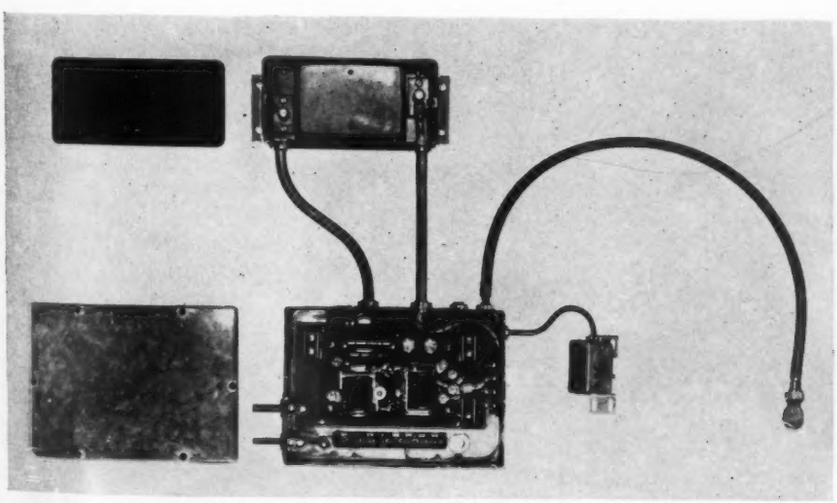


Fig. 1—Major assembly consisting of a junction box, six flexible conduit assemblies, cord plugs and receptacles. Each conduit with fittings and wires is a complete sub-assembly



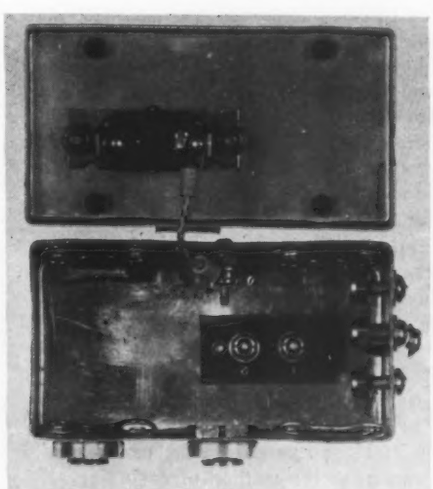
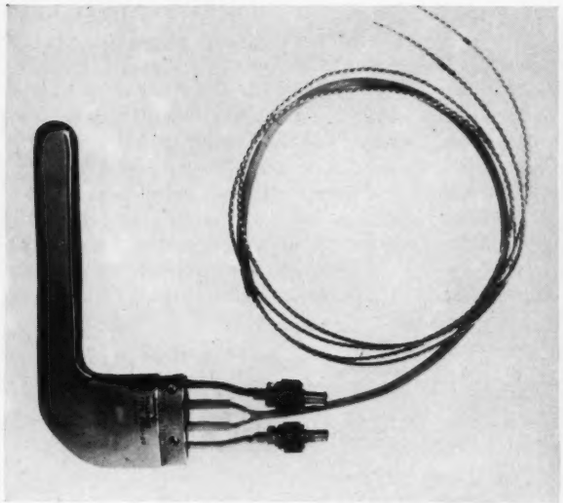


Fig. 2 (Left)—An assembly that is too large and delicate to be stocked as one unit but which is permissible because it can be installed as one unit. Fig. 3 (Right)—Junction box sub-assembly with "finger tight" screws and nuts ready for installation



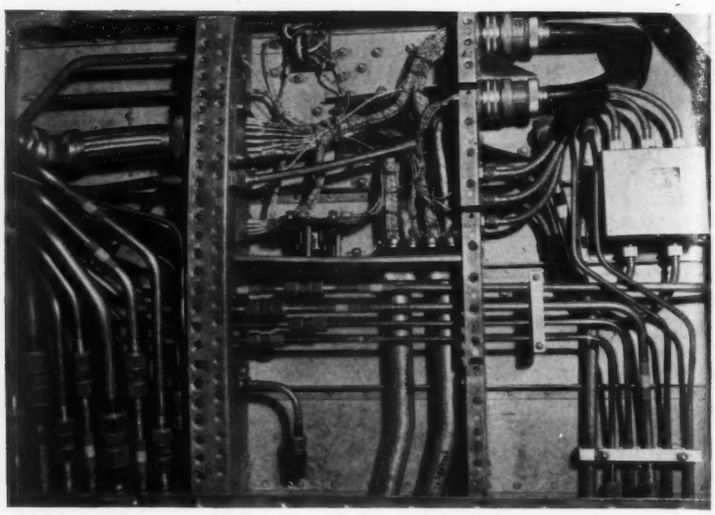


Fig. 4 (Left)—Assembly composed of members of more than one breakdown. At times it is necessary to assemble many breakdowns in order to make up a complete electrical assembly. Fig. 5 (Right)—Structure of airplane utilized for a junction box

with the thought in mind that even though it is complex or huge in size, it will be assembled on the final assembly floor. Although assemblies may be large and cumbersome, like that shown in Fig. 2, it may be possible to lift them as one unit into the airplane. If so, the assembly is permissible.

For the benefit of the shop, it is desirable to observe a few rules when electrical production assemblies are being designed.

1. Break major assemblies down into logical sub-assemblies in order to distribute the work over as much manpower as possible.

2. Complete as much work as possible on the sub-assembly before it is sent to the next assembly. If taping is required on a conduit, it should be done on the lowest sub-assembly, and all wires that make up the sub-assembly should be included. When an assembly includes a wall plug or receptable all screws, nuts and washers used on the installation should be installed on the plug or receptacle "finger tight"; that is, the nut should not be tightened with a wrench. This rule should also be followed where screws and nuts are used to install junction boxes, such as is shown in Fig. 3, to facilitate further assembly.

At the time of installation the nuts can be removed by hand and used to install the sub-assembly permanently in the airplane.

This procedure should not be followed if it is necessary to install the sub-assemblies to a subsequent assembly. Each and every assembly is a problem by itself, and no strict rules can be laid down as to the method of designing all electrical sub-assemblies.

3. Completed assemblies like the one shown in Fig. 4 may contain members of various breakdowns, for at times it is necessary to assemble plumbing, control, fuselage, wing, or members of other breakdowns in order to make up complete electrical assemblies. It is worthwhile to consider these parts as one assembly even if it becomes necessary to remove the call-out or listing in the bill of material for that part from another breakdown to an electrical drawing.

4. Keyways in receptacles and keys in mating plugs should be orientated in relation to the position of the immediate connecting flexible conduit. Straight plugs can be orientated only in their relative position to a connecting member other than their immediate connecting flexible conduit.

5. Wherever possible lugs should be installed to the sub-assemblies in their lowest breakdown. If the lugs on parts are too large to pass through a box connector change to a union may be advisable. The union can then be installed on the end of a conduit at the bench. The lugs will then be able to pass through the hole in the junction box because of the larger size required for the union. These results can also be accomplished by using a large "AN" box connector and one or two step reducer ferrules on the conduit.

6. The use of flexible conduit or unshielded wire facilitates the installation and removal of equipment assemblies and junction boxes which have several groups of wires coming from them provided that: (a) The end of the conduit away from the box has a plug or lugs on it as a means of a disconnect; (b) That if a plug is used all the structure between it and the equipment assembly must have holes large enough to allow

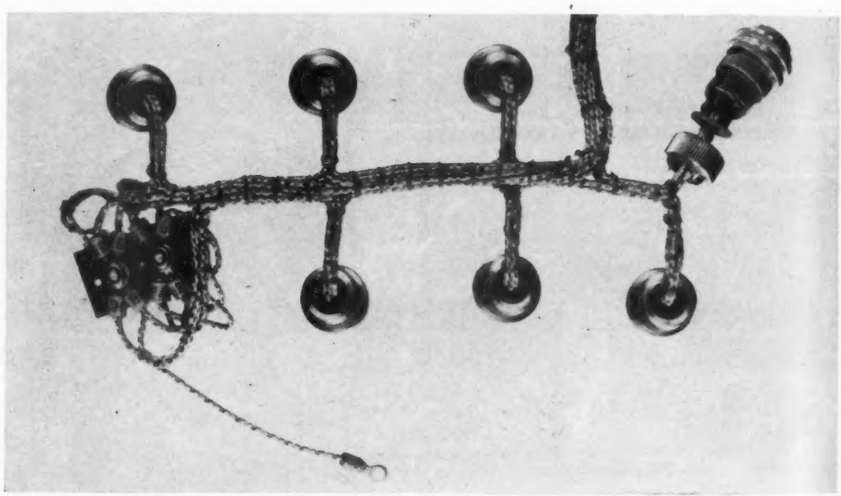


Fig. 6—Typical wire harness which consists of everything that goes into an equipment assembly except conduits are omitted

the plug with its coupling ring to be threaded into place; and (c) That if lugs are used any hole in the structure, additional conduit, fitting, or hole in the junction box must be large enough to allow the lugs to pass through. At times it may be necessary to install the lugs directly on the airplane but this is not advisable because of the fact that the close quarters involved in such installation would hamper speedy production. This condition is not bad from a production standpoint if solderless lugs are used, since few tools are necessary in the operation. If it is necessary to solder lugs or receptacles on installation the equipment used for such operation is rather awkward to handle.

7. Wherever possible utilize the advantages of the structure of the airplane itself in routing electrical wiring. For example, the openings of the corrugations in the wings may be desirable replacements of conduits.

8. If structure is used for a junction box, see Fig. 5, the designer should make equipment assemblies which consist of conduits, wires, and lugs, or wire harnesses like that shown in Fig. 6, which in general consist of everything that equipment assemblies are made up of with the omission of conduits. These assemblies can then be fed into the box, using methods mentioned in paragraphs 5 and 6. Such structural boxes will work well when used merely as junction boxes, but not when they contain several items of equipment. With the latter it is much better to use a box which will have the equipment all mounted and installed before it is placed in the ship. However, if a removable piece of structure can be utilized to mount the equipment, see Fig. 7, the assembly may be convenient. Both methods of installation have their advantages and disadvantages. It is fairly easy for water, gas and oil to seep into structural boxes. This is not so for tightly inclosed junction boxes. Therefore, it is not desirable to install structural boxes in the vicinity of liquid lines because of the possibility of those lines being fractured and consequently causing disturbances in the electrical system.

9. It is extremely important that all wire lugs or terminals be "called-out" on the proper assembly. The wires should be made up as completely as possible and entered on a wire chart or tabular detail drawing. Lugs should be called for on those drawings unless it is impossible to pull the lugs through conduits or fittings at the time of installation of the wires to their subsequent assemblies. If this condition prevails the lugs should not appear on the tabular detail drawings but rather on the drawing of the assembly or installation to which the lugs are fastened to the wire.

It is possible to include 50 detail wires on an 7x11 in. drawing. If, for example, an airplane contains about 800 wires, they can then be made into a book of the 16 sheets and released to the shop in this form. The original drawing may be large and contain all the wire data, but it should be designed so that the blueprints can be cut up into convenient book form.

The stockroom also has many problems which can be alleviated by careful consideration on the part of the designer. Illustrations of such are:

1. Large and complicated assemblies sometimes require large storage space, and not infrequently take special boxes or fixtures to hold them while they are in stock or in transit. It is desirable to "design around" these types of assemblies.

2. Breakable parts such as lamps, lenses, windows, fine instruments, or other fragile units should not be included in sub-assemblies that have to be handled or moved considerably. It is advisable to stock these parts separately, thus they can be routed directly to the final assembly department for installation on the airplane.

3. Delicate, rigid conduits, whether they be of a small diameter or irregular in shape, should not be made a part of sub-assemblies. Since they are easily damaged, they should be called out directly on installations. Damaged conduits create a rejection which in turn creates work stoppage.

The problems in the maintenance department are those which involve servicing the electrical system of the airplane.

Designers should bear in mind that:

1. Sub-assemblies lend themselves well as regards the procuring of spare parts because they can be readily stocked and kept for immediate installation. Since this factor is extremely valuable in the maintaining and servicing of military aircraft, it is advisable to design the sub-assemblies so that they can be speedily installed.

2. Sub-assemblies made in quantity lots are practically identical and thus are readily interchangeable with one another.

Since all drawings that enter the shop must have engineering approval, it is important that they conform to engineering department procedure. It is especially desirable that:

1. Procedure as specified in the drafting room manual be followed in the makeup of the electrical production assembly drawings. Any deviations desired should be authorized by the engineering management.

2. Engineering groups, other than the electrical, affected by production assemblies should be notified of any change that may interfere with the composition of their drawings, and should then cooperate to the fullest in revising their drawings if it is found advisable.

There should be no question in the mind of the designer as to the advisability of designing production assemblies. The name "production assemblies" is self-explanatory. Obviously it is not wise to design production assemblies for an experimental model. It would be far better to release the electrical design on experimental drawings. After the experimental model has been designed, built and flown, or has proved itself, then is the time to consider production assemblies if there is sufficient quantity of that model on order to warrant the additional labor required to convert the experimental model to a production model.

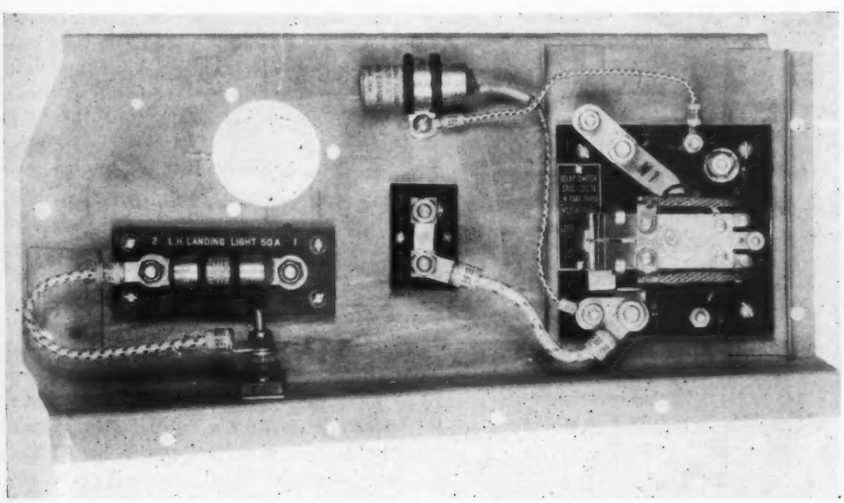
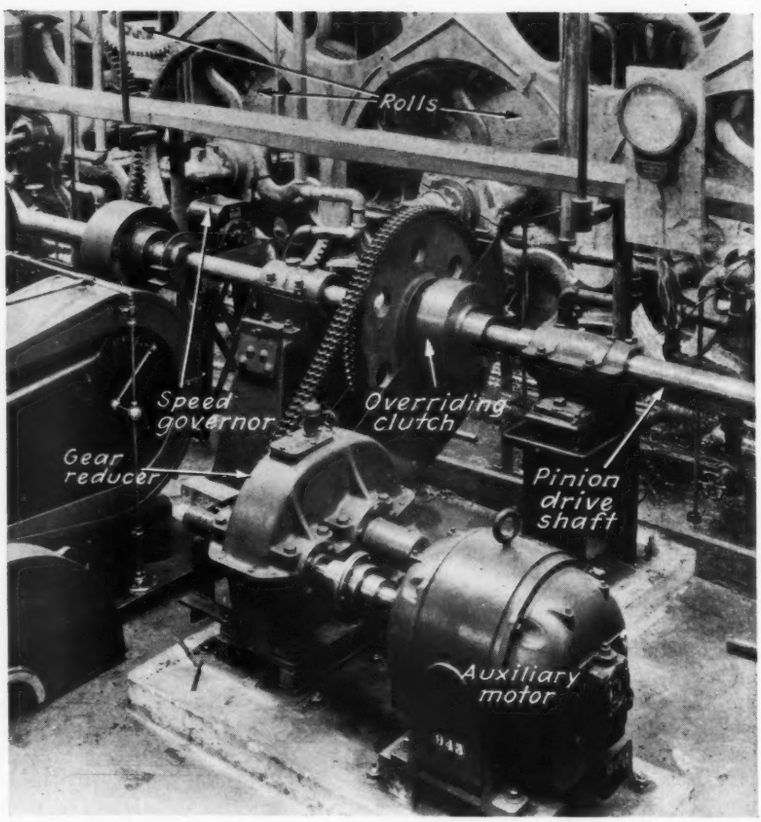


Fig. 7—Removable structural member used as a mount for electrical equipment. An assembly of this type generally is easily installed

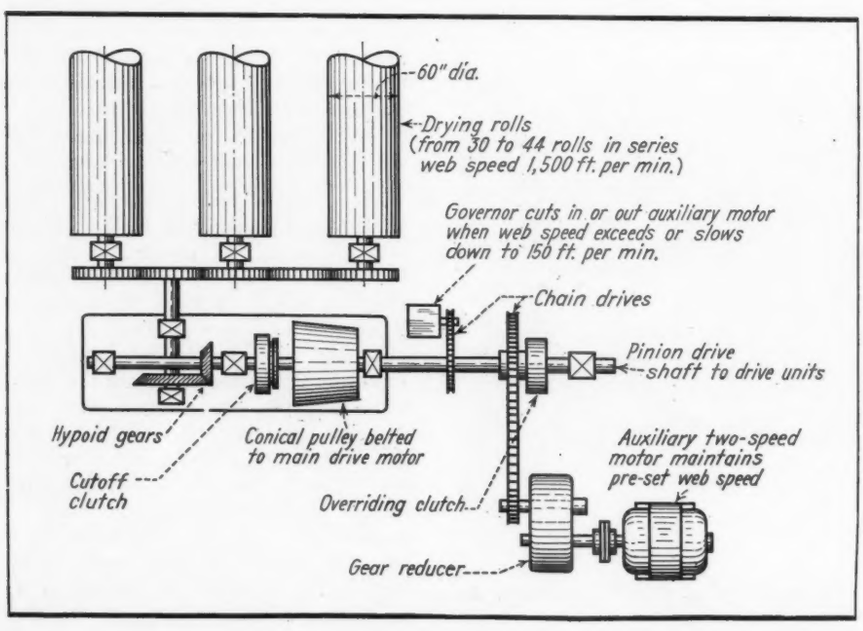
Modern Designs

Auxiliary Drive for Starting Heavy Rolls

Rotating mass of dryer sections on high-speed (1,500 ft. per min.) paper machines weighs approximately 1,000,000 lb., and when mechanical drives are used the problem of starting and accelerating is one of considerable magnitude. To overcome this difficulty, Rice Barton Corporation has designed a two-speed auxiliary drive. Main drive comprises a hypoid unit, mechanical or magnetic clutch of the cut-off type, and tapered cone pulley. Auxiliary drive consists of two-speed motor, gear reducer, chain drive to over-riding clutch and centrifugal governor.

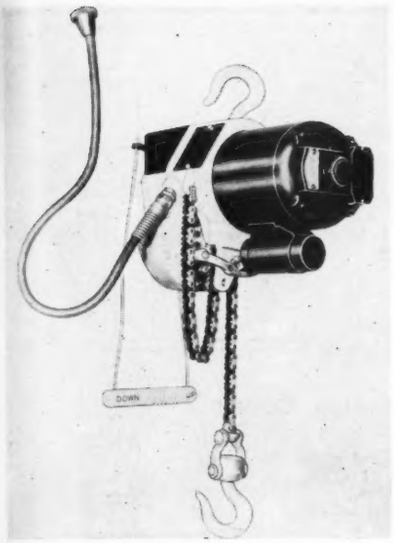


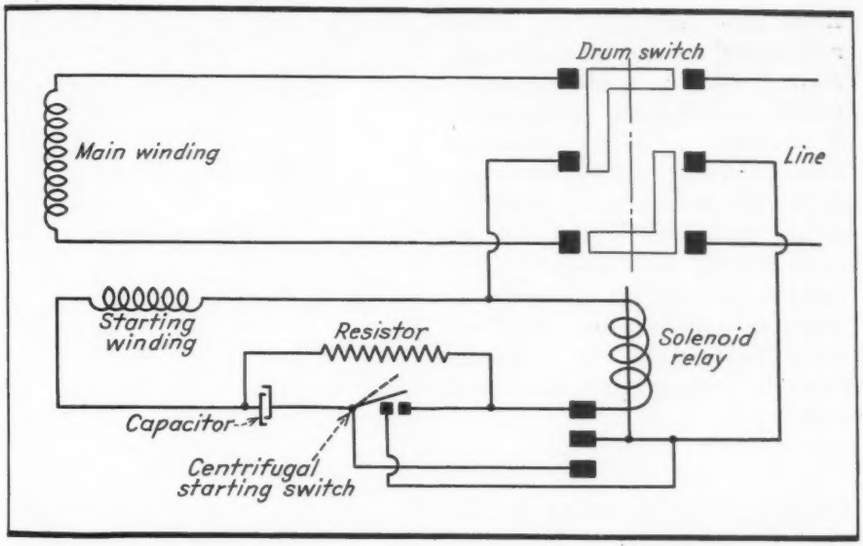
When starting the paper machine, the slow speed of the two-speed auxiliary motor is used to provide sufficient breakaway torque. As soon as a section has started, the second speed of the motor is used to accelerate the dryers to approximately 150 ft. per min., at which point the main drive clutch is engaged to further accelerate the section to running web speed of 1,500 ft. per min. Step type of motor controller is used for smooth acceleration.


60" dia.
Drying rolls (from 30 to 44 rolls in series web speed 1,500 ft. per min.)
Governor cuts in or out auxiliary motor when web speed exceeds or slows down to 150 ft. per min.
Chain drives
Pinion drive shaft to drive units
Hypoid gears
Cutoff clutch
Conical pulley belted to main drive motor
Overriding clutch
Auxiliary two-speed motor maintains pre-set web speed
Gear reducer

As soon as clutch is engaged to bring the machine up to its final speed, the centrifugal governor automatically stops the auxiliary motor and the overriding clutch allows the pinion shaft to operate at the final machine speed. If the operator wishes to bring the machine to a complete stop, he disengages the clutch, which is automatically interlocked so that the auxiliary motor will not start, and the machine comes to rest. If the paper should break and "plug up" in the dryer section, the operator disengages the clutch and pushes a "slow" button as though stopping the machine. Then as the machine slows up to 150 ft. per min., the centrifugal governor closes and starts the auxiliary motor, which holds the machine speed up to approximately 50 ft. per min. for removing the "broke." Details of hypoid drive unit are given in PRODUCT ENGINEERING, April 1941, page 196.

Plug Reversing Motors



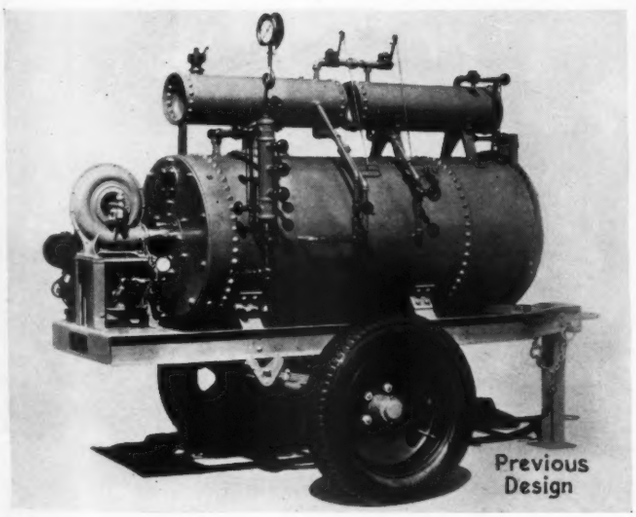


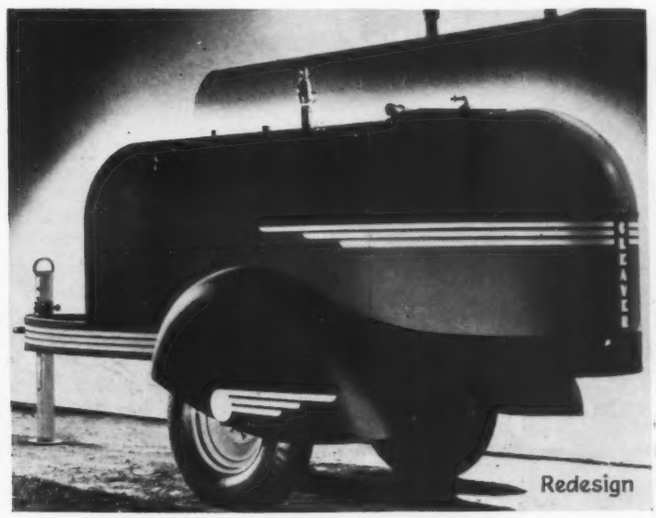
To apply split-phase or capacitor-start motors for plug reversing service instead of the higher maintenance repulsion-start induction type on hoists (above), cranes, lathes and door openers, Westinghouse engineers worked out this circuit. Mounted in the motor are a two-contact centrifugal switch; a solenoid relay; and in capacitor motors, a resistor. Control mechanism is a drum switch or equivalent. Capacitor unit (when required) is placed in the auxiliary winding circuit.

Motor is started in selected direction by closing the drum switch, setting up a power circuit through the relay coil and the motor windings. Line voltage across the solenoid relay causes it to pull in and lock itself across the line, transferring the circuit from lower to upper contact. Line voltage across the motor main and starting windings (including capacitor and resistor in capacitor-start motors) causes the motor to start in selected direction. At a predetermined speed, the centrifugal starting switch opens, cutting out the starting winding. The motor then operates on the main winding as an ordinary single-phase induction motor.

To plug-reverse the motor, the reversing drum switch is thrown to the other side. This reverses the starting winding connections with respect to main windings. The solenoid relay, by dropping to the lower contact, inserts the reversed starting winding into the circuit, electrically braking the motor and starting it in opposite direction.

Metal Spinning, Standard Parts Specified



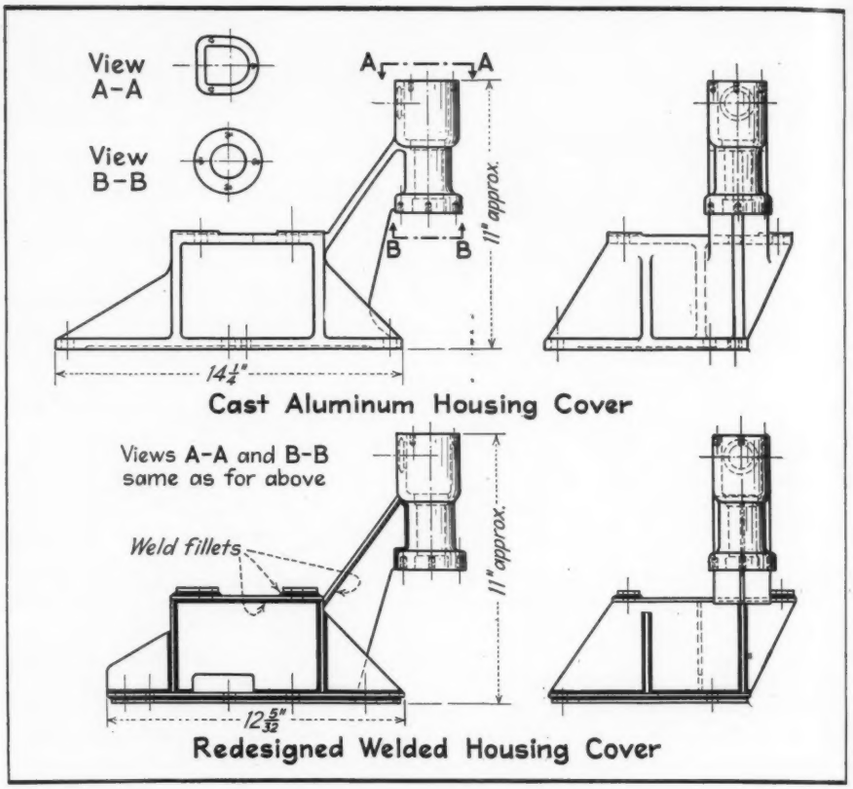


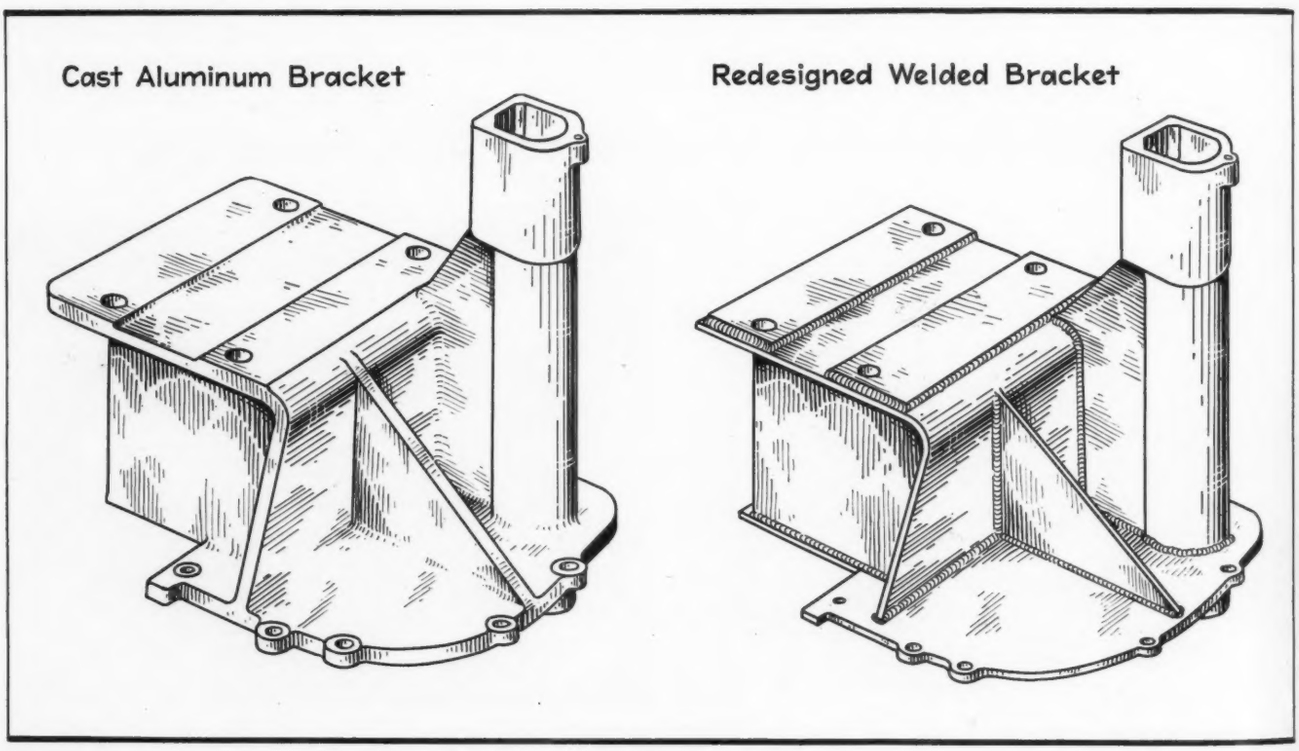
Tank car heater of Cleaver Brooks Company was redesigned by tucking water tanks under boiler, rearranging other projecting parts for compactness, and adding streamlined housing. Object: lower center of gravity and streamlining for easier towing behind automobile, and improved appearance. Rear section of dome is metal spinning; fenders are standard automobile. Space between boiler and steel lagging is insulated with rock wool. Inclosure over standard atomizing type oil burner and condensate assembly is hinged for accessibility. Water tanks are now arc-welded; four-pass, downdraft boiler is riveted. Welded frame is constructed from channel iron.

MODERN DESIGNS – Gun Mounts Use Less Aluminum

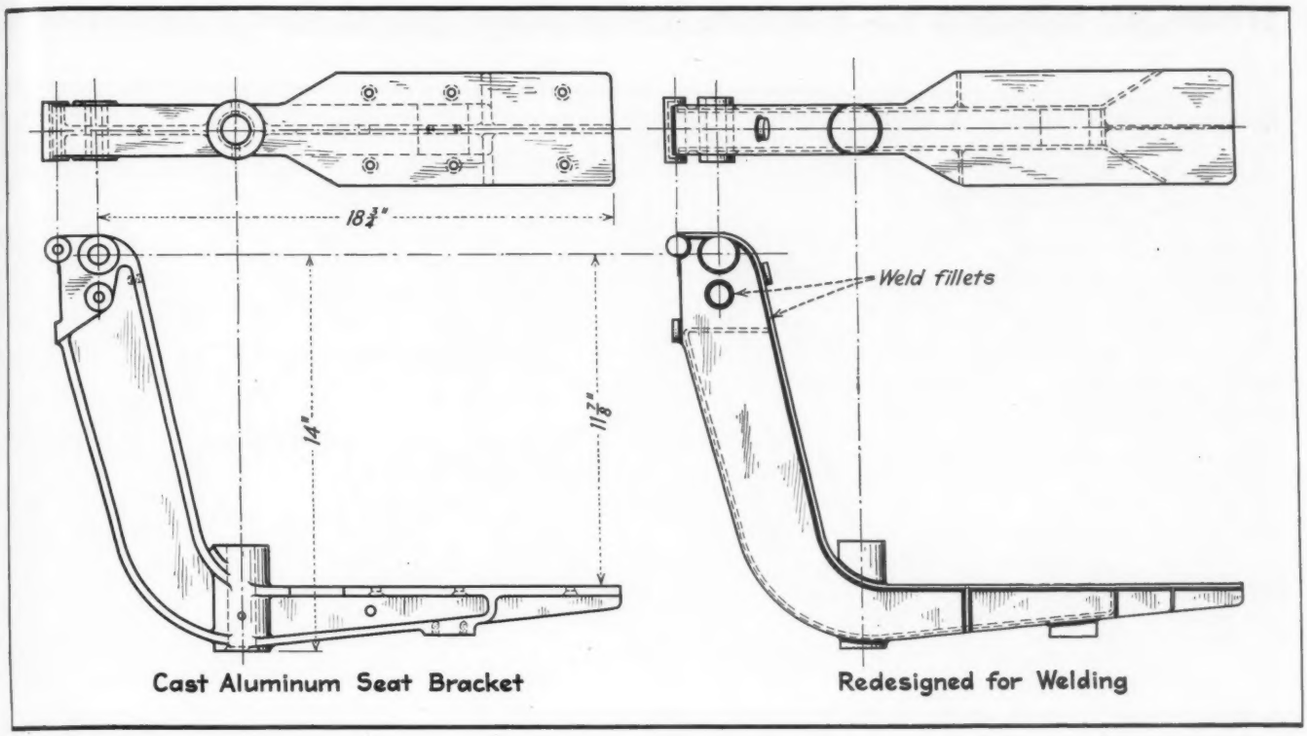
Even gun carriages are being redesigned to conserve strategic materials badly needed in other phases of defense production. Watertown Arsenal engineers have replaced aluminum castings with welded steel designs, giving particular attention to maintaining low weight. The arsenal has also substituted malleable iron and steel castings for some bronze castings — design changes calling only for new patterns.

Housing cover for anti-aircraft gun mount was formerly an aluminum alloy casting, heat-treated to 28,000 lb. per sq. in. tensile strength. The cover is now fabricated from steel plates and a small casting, welded into a unit which is as strong and almost as light as the previous aluminum casting. Weld fillets are ⅛ in. and, except for the base and bosses which are of $\frac{5}{16}$-in. plate, ⅛-in. steel plate is used.



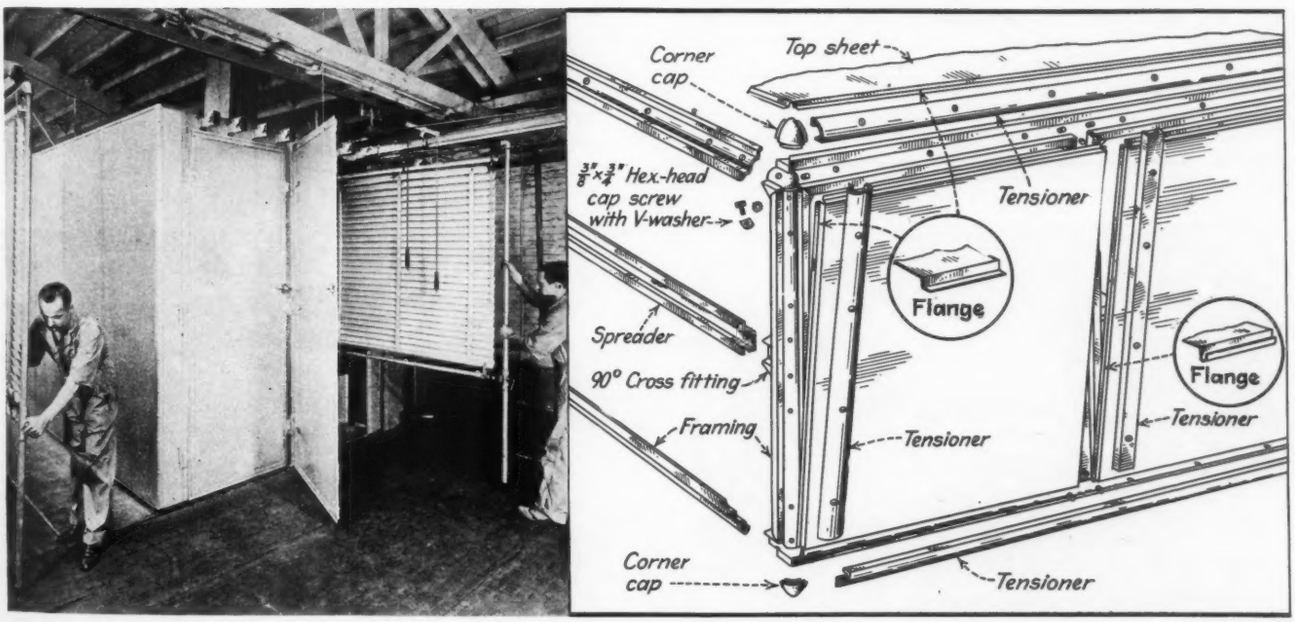


Thinner sections, cutouts in ribs, and minimum boss areas give the welded steel bracket at right nearly the same weight as the cast aluminum bracket at left. Aluminum sections were $\frac{5}{16}$-in. thick; steel plate is ⅛-in. thick. The bracket is $12\frac{5}{16}$ in. high, 9¾ in. wide, and $12\frac{3}{8}$ in. long. Machining instructions for the two parts are practically identical, with tolerances of 0.005 in. allowed for most center-to-center distances.



Seat bracket for anti-aircraft gun carriage is now welded from 8 pieces of ⅛-in. steel plate and 7 bosses and blocks cut from 1020 steel bar stock. So closely identical is the welded bracket with the previous cast aluminum bracket that arsenal engineers have referred the shop to the old blueprint for machining instructions.

Blind Laundry Has Prefabricated Housing



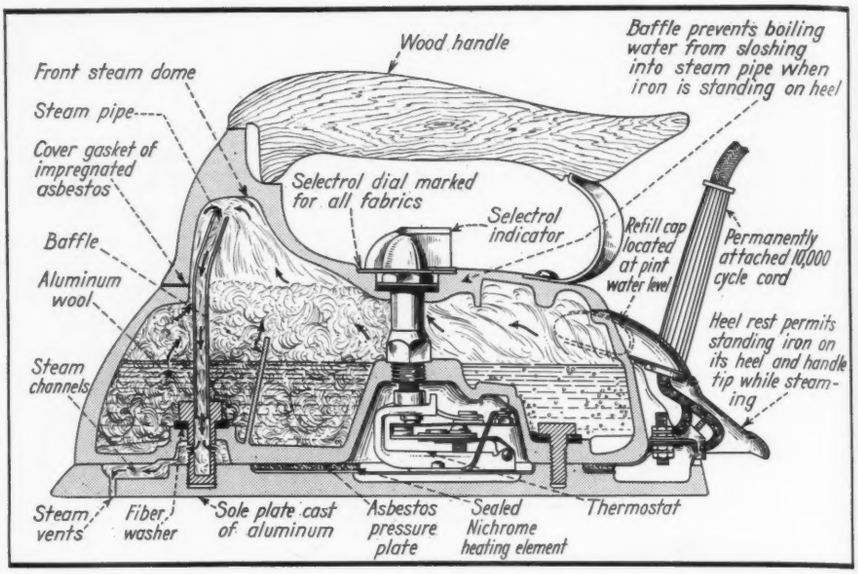
Local space requirements for venetian blind washers manufactured by Venetian Blind Laundry, Inc., are met by this light-weight, prefabricated steel housing construction. Standard framing and standard sizes of sheets are supplied so that the washer unit can be constructed to fit practically any space. The housing can be assembled quickly by unskilled workers, without riveting or welding, and new additions can quickly be made. Details of the Lindsay Structure are shown at right.

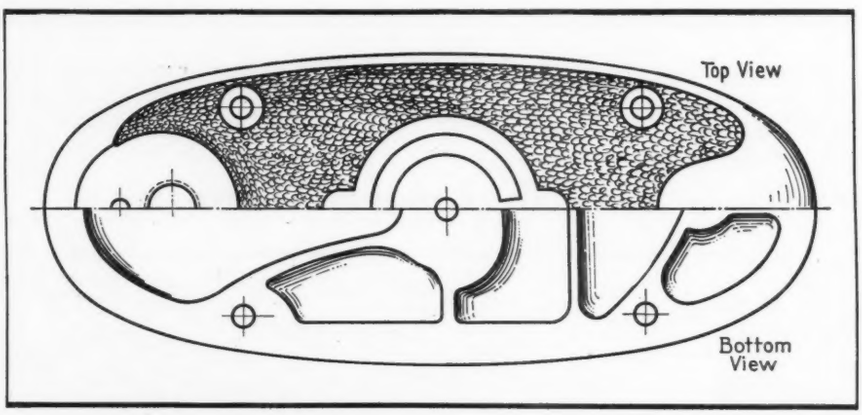
Blinds to be cleaned are hung on steel frames carried on overhead monorail tracks, and are carried into washing chamber where they are sprayed with a washing solution and scrubbed with long, soft brushes. When clean, they are rinsed and moved to drying compartment in which air at a temperature of 110 to 120 deg. F. is circulated. Housing structure has ample strength to carry roof load.

MODERN DESIGNS – Steam Iron Designed for Lightness

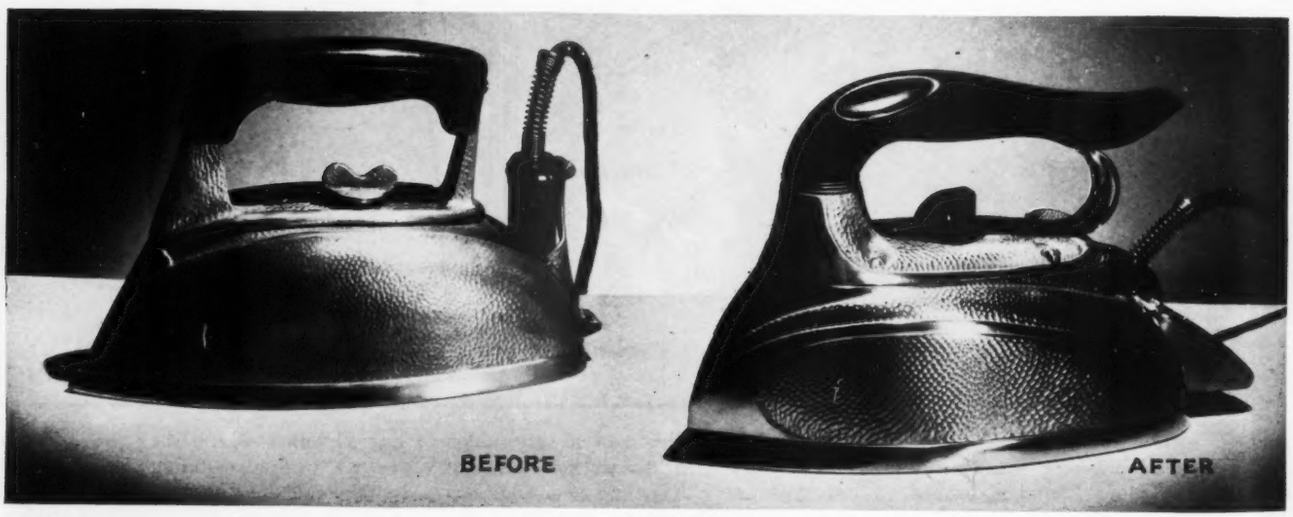
Principal consideration in redesign of Steam-O-Matic iron was to overcome unsaleability of large size and weight resulting from 1-pint water capacity. Self-contained boiler type iron is controlled by adjustable linear expansion type thermostat which governs temperature of sole plate whether iron is dry or filled. Heating element is nichrome wire wound on mica core; core is sandwiched between two mica plates. Complete element is inclosed in copper for thermal conductivity.

To make it possible to stand iron on heel plate while steaming, a ⅛-in. dia. aluminum tube extends from steam vents up into steam dome; opening of pipe is above water level at all times. Interior of water compartment is filled with aluminum wool and is baffled to prevent surging of water.


Wood handle
Baffle prevents boiling water from sloshing into steam pipe when iron is standing on heel
Front steam dome
Steam pipe
Cover gasket of impregnated asbestos
Selectrol dial marked for all fabrics
Selectrol indicator
Refill cap located at pint water level
Permanently attached 10,000 cycle cord
Baffle
Aluminum wool
Heel rest permits standing iron on its heel and handle tip while steaming
Steam channels
Steam vents
Fiber washer
Sole plate cast of aluminum
Asbestos pressure plate
Sealed Nichrome heating element
Thermostat

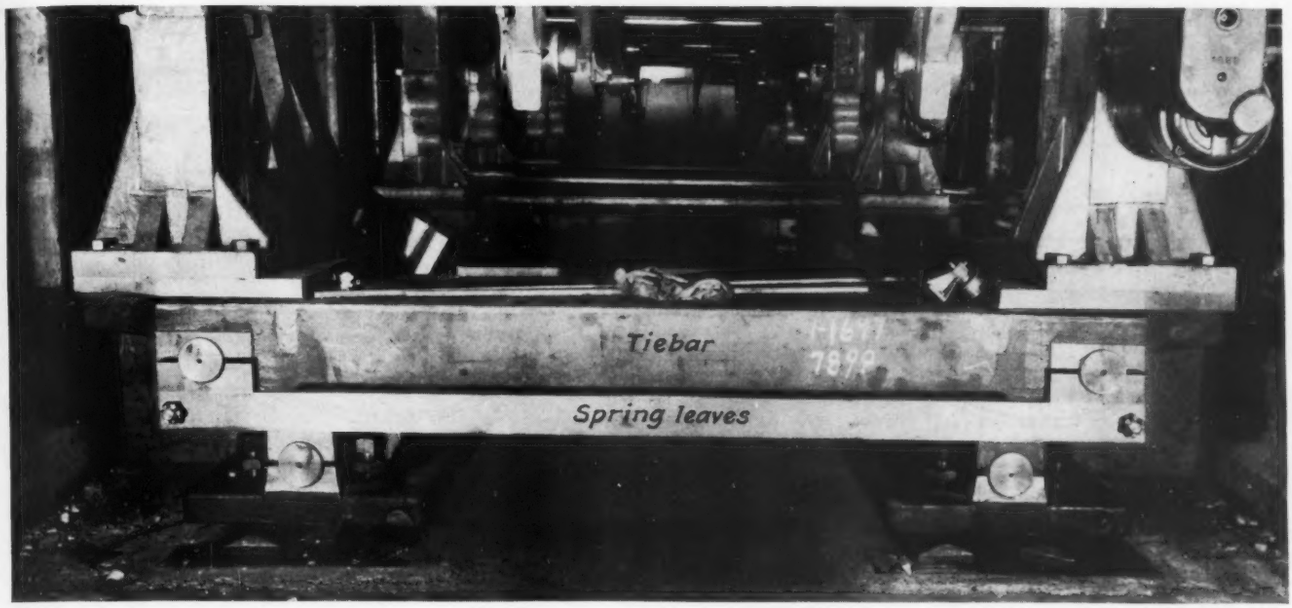


Coverplate, elliptical in shape, is constructed so that excess pressure will cause it to bend so steam can escape. Mounting screws are 3½ in. apart. Body and cover are of aluminum alloy, 6 percent copper, 3 percent silicon, 89 percent aluminum. Soleplate is of extra-hard aluminum alloy, and all interior parts are of aluminum. All aluminum parts with exception of soleplate are anodized. Reasons for all-aluminum construction are light weight, corrosion resistance, and uniform coefficient of thermal expansion for all mating parts. No satisfactory substitute for aluminum has yet been found.



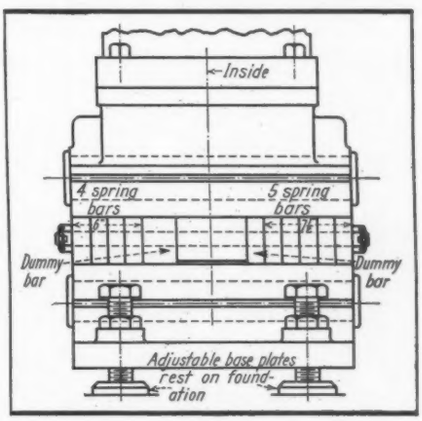
Comparison of redesigned iron with old design shows how polished bead around casting makes iron appear lighter in weight by reducing illusion of height. Graceful handle design is limited to compound curves which can be reproduced by manufacturers of wood handles. Hammered finish was selected because it camouflages pits which frequently occur in aluminum castings. Brooks Stevens did the redesign job for Steam-O-Matic Corporation.

Spring Mountings Dampen Press Vibration

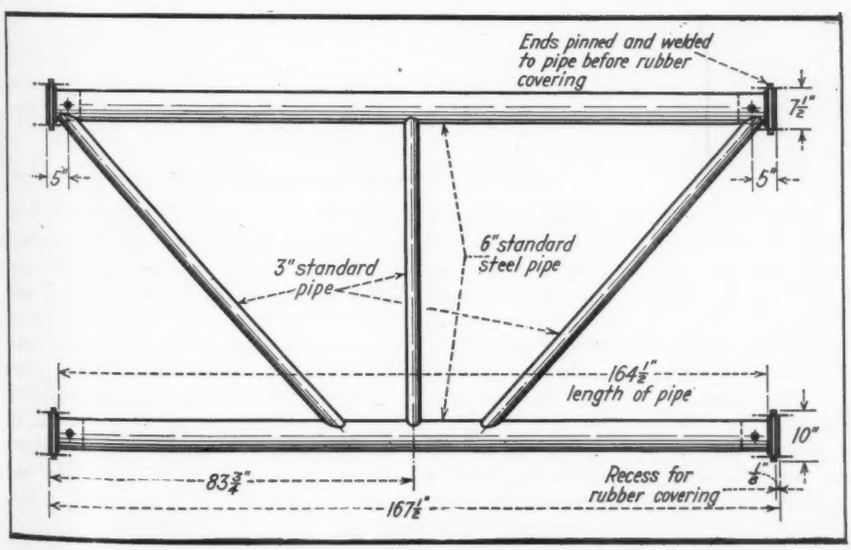


High-speed rotary presses consist of several printing and folding units set up in line. Therefore, vibration isolation devices should be designed of materials that will not deteriorate during ten-year life of the press or take a permanent set that will throw units out of line. Goss Printing Press Company recently patented this continuous beam spring mounting having two pivoted supports and two overhanging unsymmetrical loads. Friction in pivots dampens as much as 96 percent of vibration. Typical installation with seven printing and one folding units has three pairs of spring mountings running lengthwise and a single mounting running crosswise near center.

Each spring mounting consists of several flat spring steel (SAE 2340) leaves set on edge and fastened at ends by through-bolts. Spring assembly is carried on saddles which form bearing for lower pivot pins. Tie frame between columns is supported on upper pivots. Column loadings vary, so uniform deflection for all spring units is obtained by varying number of leaves in springs and by varying relative position of lower and upper pivots. Standardized unit is designed for 12 springs; where fewer are required, dummy bars are inserted.

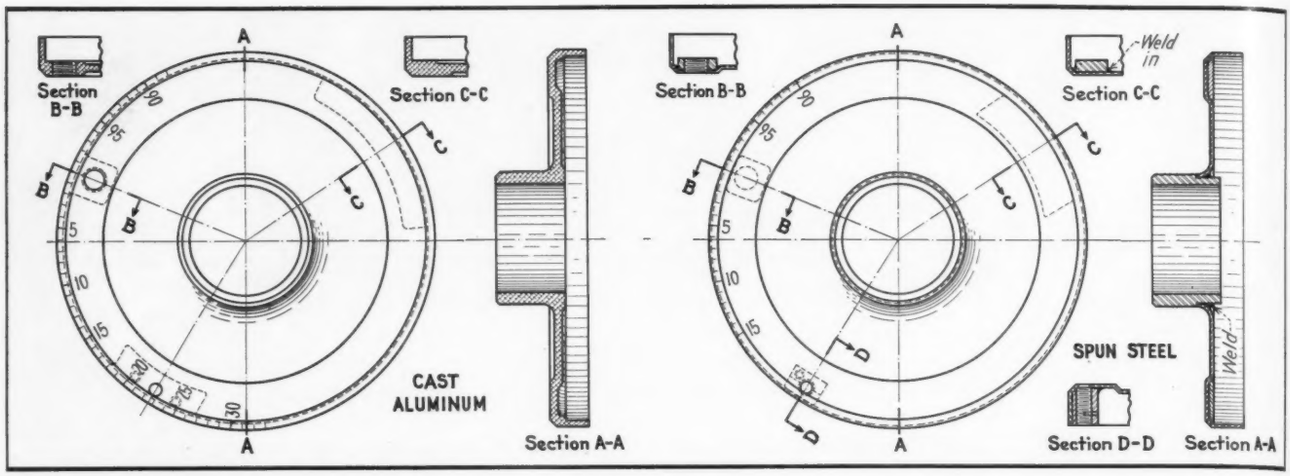


Rubber for Corrosion Resistance



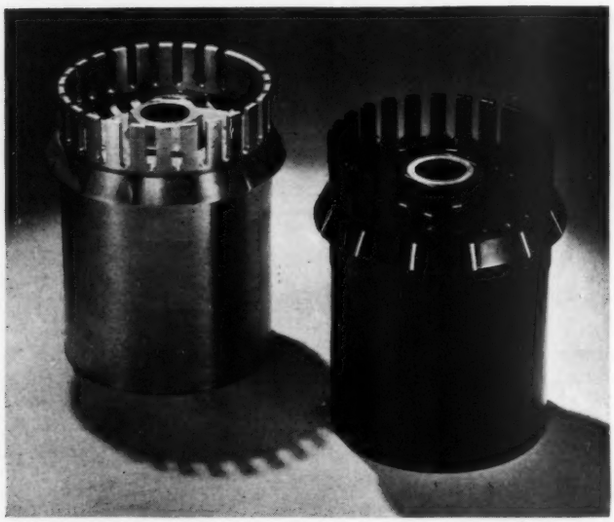
Cross braces for Rice Barton fourdrinier machines are welded from steel pipe as shown at right, and are subject to severe corrosion from "white water" which splashes down on them. Pipe diameters vary from 2½ to 8 in., and lengths vary from 8 to 22 ft. Rice Barton Corporation previously protected the braces by pulling brass or Monel tubes over the pipes and brazing the joints. Copper was temporarily substituted when these metals became scarce. Good corrosion-resistance is now obtained by vulcanizing a coating of rubber over the complete brace after assembly by welding. Coating is slightly less than ⅛ in. thick, is non-porous, and has excellent resistance to mechanical abuse. Cost compares favorably with that for Monel.

MODERN DESIGNS – Dials and Handwheels Redesigned

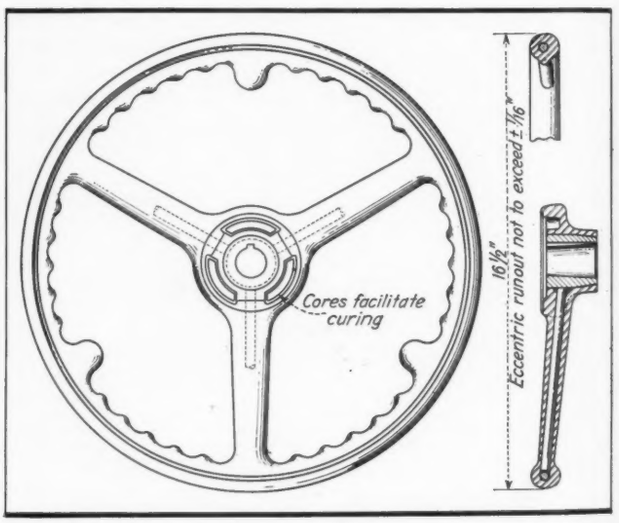


Cast aluminum graduated dial for vertical surface grinder will be made of spun steel when aluminum runs out. Chief requirement of material for this part was lightweight for minimum inertia. Dial is geared to handwheel and spins at about 200 r.p.m. under power rapid traverse. Handwheel itself spins at 800 r.p.m.; it also is made of aluminum, but substitute is undecided.

The dial now consists of a steel spinning approximately 0.093 in. thick, two small lugs, and a hub turned of steel tube stock, all assembled by brass brazing. To counterbalance the two lugs, another small steel piece is brazed on diametrically opposite. Spun dial must be normalized after brazing and respun to correct concentricity. Dial is cadmium plated when finished. The 45-deg. bevel around the outside of the dial is machined; rest of the dial is merely polished before the graduations are engraved by cutters. The only tools required for the spinning are two steel chucks costing about $92. Cost of spinning and brazing is $6.50 per piece, to which must be added the cost of the hub, cost of the other three small parts, cost of the engraving, cost of the plating and polishing. Total cost of the spun dial, therefore, is close to the $14.50 cost of the cast aluminum dial.



Plastics replaces an aluminum casting in Warner and Swasey's "Preselector"—a device mounted on a turret lathe headstock to permit the operator to preselect his work speeds and shift gears and to permit him to operate the clutches and head brake with a single lever. Production of plastic dial drums saves 1,400 lb. of aluminum each month and has reduced manufacturing costs 80 percent. The only machining required on the phenolic resin drum is drilling a small oil hole. Plastic and aluminum preselectors are identical in all dimensions, with the exception that the plastic castellations are reinforced by ribs. This was not possible with the aluminum dial drum because machining was necessary both inside and out.



Hard rubber vulcanized over a welded core of $\frac{11}{32}$-in. steel rod gives Warner & Swasey a turret lathe handwheel that is lighter and less expensive than the previous cast aluminum handle. Three spoke cores in new wheel are welded to cast iron hub and to rim core. Shape of wheel differs only slightly from that of cast aluminum wheel; one difference is in cored recesses in rubber around hub, done to facilitate curing. Hard rubber handwheel is supplied finished to a high polish, and requires no turning and boring operations as were necessary for aluminum wheels. Hard rubber specified is same as for steering wheels in trucks and tractors. Two sizes are being made: 16½ and 20 in. dia. Substitution is permanent.

FABRIC ATTACHMENTS – II

Test Results and Specifications for Improved Lacing

A. MERRICK BLAMPHIN

THE STRENGTHS of the component materials in fabric coverings and factors that influence the strength and efficiency of laced attachments were discussed in Part I (November *P.E.*). This concluding part of the article goes into further details, explains design procedure, and presents a graphical method, developed by William H. Miller of the Bureau of Aeronautics, for calculating ultimate design pressures on upper surface of airfoils.

Types of Knots

Another phase of the investigation was devoted to the study of the efficiency of the knots used for the stitch tie-off and for joining separate pieces of lacing cord. The knot most commonly used for the stitch tie-off is shown in Fig. 6. When properly tied, this knot, called the Seine knot, is fairly secure, but its construction is such that it may easily be tied in the false form shown in Fig. 7, which has no security at all. After considerable experimenting the improved knot shown in Fig. 8 was adopted as the standard for stitch tie-off purposes. This knot is easy to tie and cannot be tied improperly. Its strength as demonstrated by tests is slightly greater than the Seine knot and it provides excellent security for initial tension in the lacing cords.

It can easily be demonstrated that two ends of waxed lacing cord joined together by a square knot can be slipped and pulled completely apart with a pull of 10 to 20 lb. Obviously when this knot occurs in the loaded cord on the inside of the wing between the upper and lower covers it represents a potential weak point in the lacing attachment. The splice knot shown in Fig. 9 is the most efficient of the many which were tested. This knot develops a strength of approximately 35 lb. and if properly tightened will not show any appreciable slip.

Stress Design of Laced Cover Attachments

It has been demonstrated how laced cover attachments can be assembled by production methods to show a strength of 60 lb. per stitch. It must be

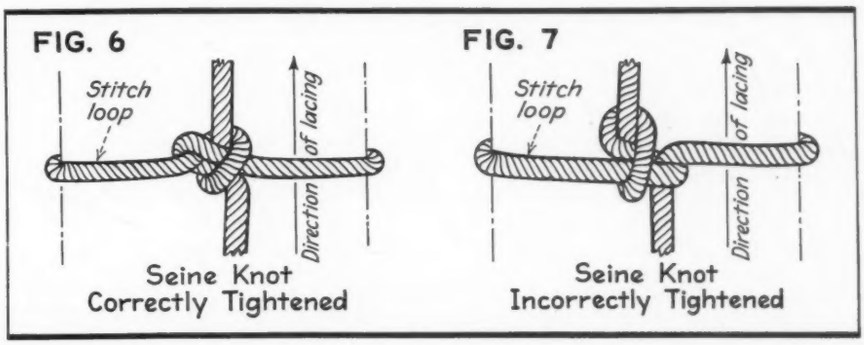


Fig. 6—Seine knot is the one most commonly used for the stitch tie-off. When properly made it is fairly secure. Fig. 7—A falsely tied Seine knot of no security results when knot is not tightened correctly

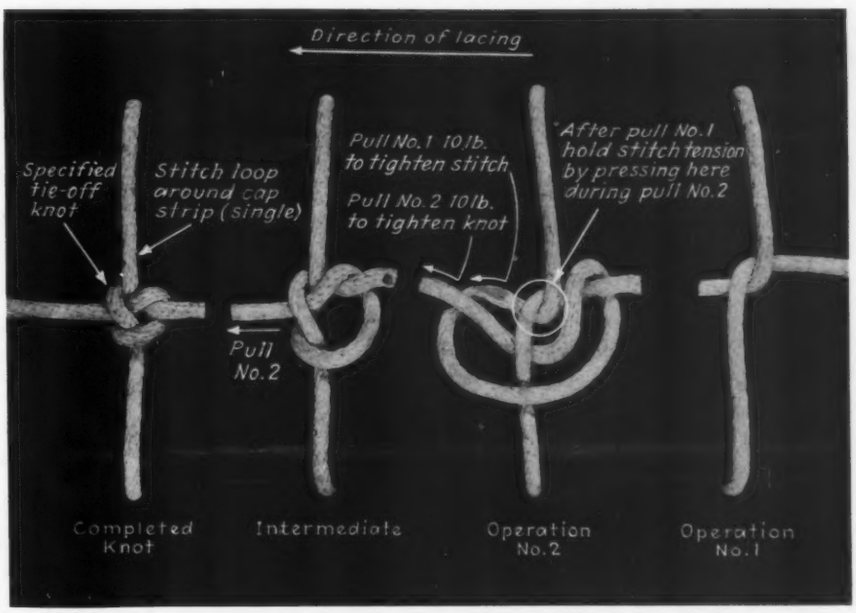

Direction of lacing
Specified tie-off knot
Stitch loop around cap strip (single)
Pull No.1 10 lb. to tighten stitch
Pull No.2 10 lb. to tighten knot
After pull No.1 hold stitch tension by pressing here during pull No.2
Pull No.2
Completed Knot
Intermediate
Operation No.2
Operation No.1

Fig. 8—This improved knot is simple to make, cannot be made ineffective by improper tightening and is stronger than the Seine knot

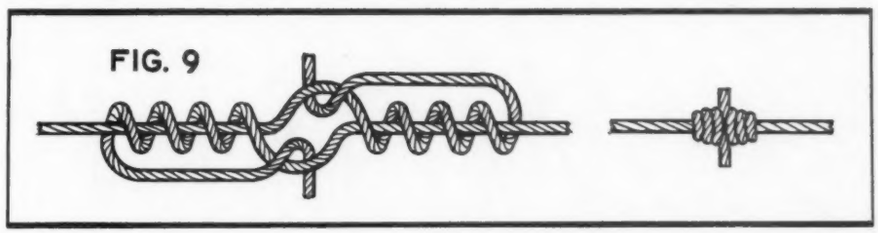


Fig. 9—The common square knot in waxed cord pulls apart under tension. The splice knot shown here is the most efficient of many tested, develops a strength of approximately 35 lb. and will not show any appreciable slip if it has been tightened properly

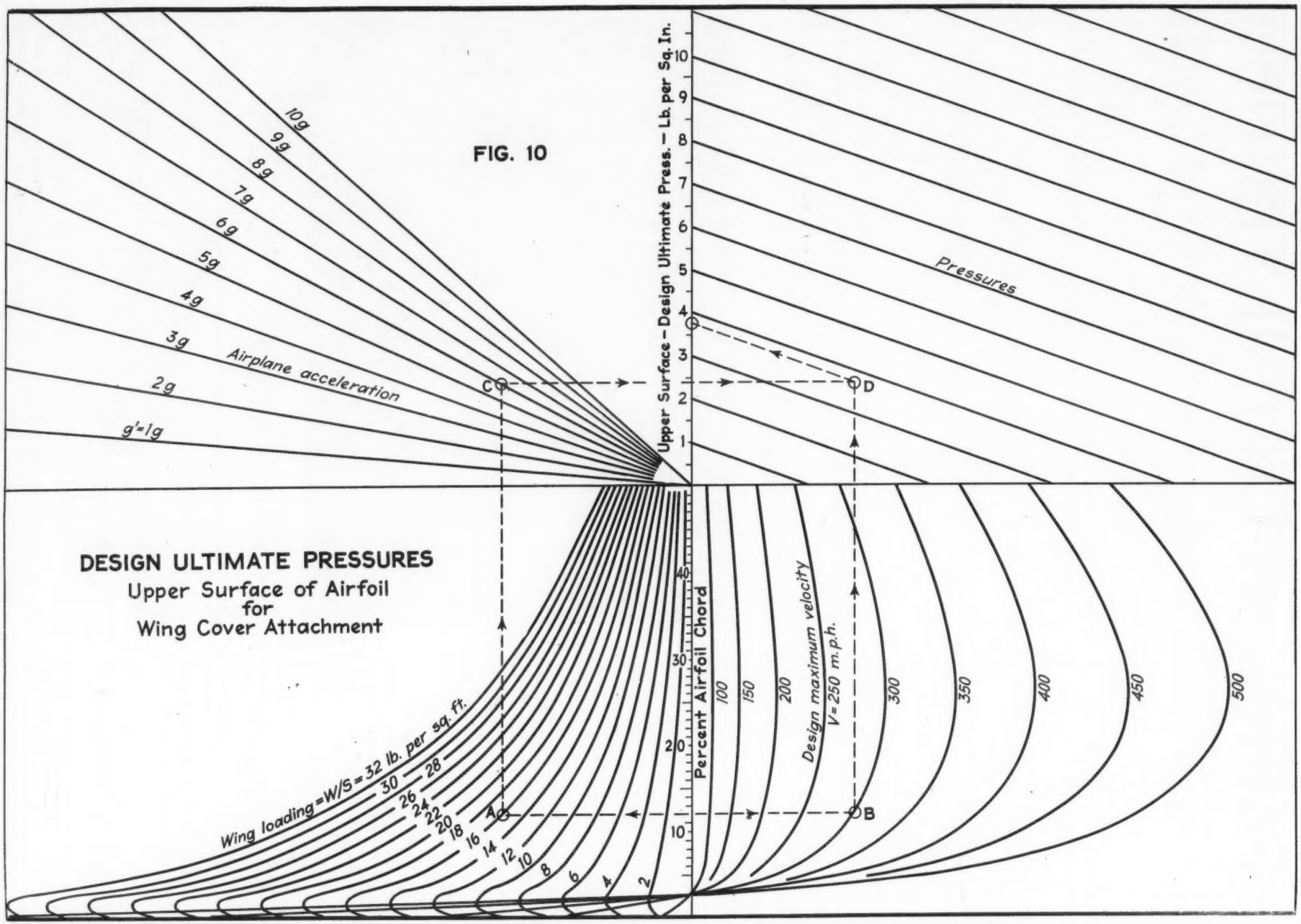


Fig. 10—Graphical solution for the determination of design ultimate pressures imposed on wing surfaces

remembered that this strength applies only to covers assembled from component materials identical with or equal to those used in the tests and to a plain capstrip one-half inch wide. In all individual cases the allowable stitch strength should be determined from actual pressure blow-off tests using the same component materials, capstrip and rib spacing which are to be used in the particular airplane under construction. The exact stitch strength determined from these tests, which may be anywhere from 40 to 70 lb., depending on the materials used, may then be employed as the basis of the stress design of the whole cover assembly. The next step is to determine the maximum load which will be imposed in flight. The number of stitches per lineal inch of capstrip required to take this load can then easily be calculated.

The design ultimate pressure (negative) at any point on the upper surface of a wing depends upon the airfoil section used and is a function of the maximum velocity, the wing loading, and the maximum acceleration which is permitted to be developed in flight. Since this pressure is a function of the characteristics of the individual airfoil used, a simple expression cannot be derived to apply to all airplanes. For the purpose of simplifying the work and calculation, however, a relationship may be evolved based on "envelope" curves of values of maximum upper surface pressures for any given series of airfoils, including correction factors to allow for peaks in the spanwise loading and for biplane effect as applicable. A factor of safety equal to that allowed for the wing structure at yield must be included also. In Fig. 10 is shown a graphical solution of a quantitative equation derived to express this "envelope" relationship as applicable to a particular series of airfoils. As an example to illustrate the method of using a chart of this type, assume:

$$\text{Wing loading} = \frac{W}{S} = \frac{\text{Gross weight}}{\text{Total wing area}}$$

$$= 16 \text{ lb. per sq. ft.}$$

$$\text{Maximum acceleration} = g' = 6g$$

$$\text{Maximum velocity} = V = 300 \text{ m.p.h.}$$

Also assume that the lacing will begin at the rear edge of the front beam, at a point aft of the leading edge equal to 12 percent of the chord.

Enter the graph on the vertical line marked "Percent Airfoil Chord" at 12 percent and draw a horizontal line through this point intersecting the curved parametric line for $W/S = 16$ lb. per sq. ft. at A and the curved parametric line for $V = 300$ m.p.h. at B. From A draw a vertical line to intersect the parametric line for acceleration, $g' = 6g$ at C. From C draw a horizontal line to intersect at D, a vertical line drawn from B. Project point D parallel to the parametric lines of "Pressures" to the vertical scale marked "Upper Surface Design Ultimate Pressures" and read the value which, in this example, is 3.75 lb. per sq. in. Since this design ultimate pressure applies only to the low angle attack condition it is advisable to investigate the pressure at the same point for the high angle of attack condition which, in this particular case, corresponds to

$$C_L = 2.0$$

$$\text{Then} \quad V = 14\sqrt{g' \times W/S}$$

$$= 14\sqrt{6 \times 16}$$

$$= 137.2 \text{ m.p.h.}$$

Proceeding with the aid of the chart as above, the design ultimate pressure at 12 percent of the chord for high angle of attack = 2.70 lb. per sq. in. Pressures for both low and high angles of attack are investigated for a number of points along the chord as follows:

Percent Chord	High Angle Attack V=137.2 m.p.h.	Low Angle Attack V=300 m.p.h.
5	3.63	4.25
10	2.95	3.95
12	2.70	3.75
15	2.45	3.55
	1.825=$P_{max.}/2$	
25	1.80	3.00
35	1.35	2.55
		2.125=$P_{max.}/2$
50	0.85	1.80

Curves similar to those shown in Fig. 11 may then be plotted to show the distribution of the pressure. From the above, we find that the design ultimate pressure is 4.25 lb. per sq. in. at 5 percent of the chord, for the low angle of attack condition. Since this pressure occurs forward of the beam and stitch-

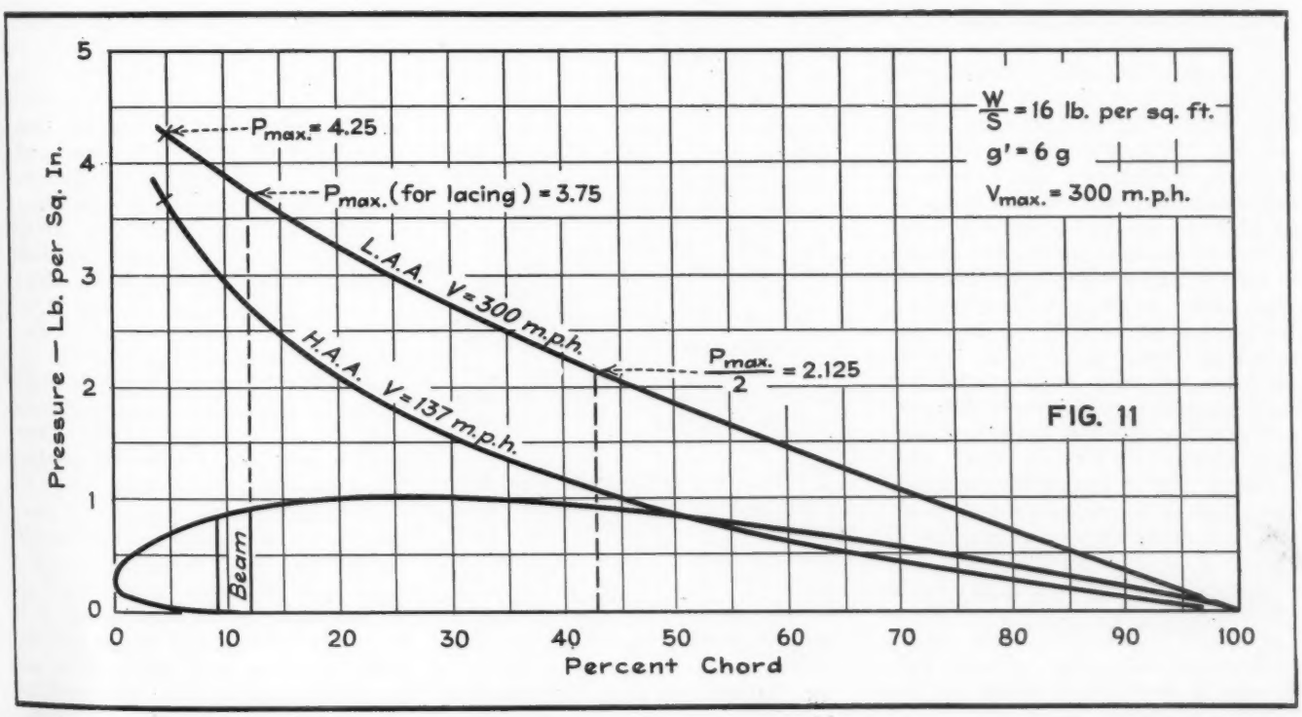


Fig. 11—Curves such as this are plotted from the calculated pressures to show the distribution of pressure over wing surface

Fig. 10—Graphical solution for the determination of design ultimate pressures imposed on wing surfaces

ing, the design ultimate pressure applicable to stich loading is 3.75 lb. per sq. in. as shown before. Given a proved stitch strength of 50 lb. and rib spacing of 10 in., the number of stitches required per inch is,

$$N = \frac{\text{rib spacing} \times P}{\text{stitch strength}}$$

$$= \frac{10 \times 3.75}{50}$$

$$= 0.75$$

and stitch spacing will be,

$$S = \frac{1 \text{ in.}}{N} = \frac{1 \text{ in.}}{0.75} = 1.333 \text{ in.}$$

For simplification use the next lowest one-quarter inch, or $S = 1\frac{1}{4}$ in. Thus, it is determined that in the example above, a laced cover attachment with stitch spacing of $1\frac{1}{4}$ in. will carry the peak pressure with a factor of safety of approximately 2.0. This factor of safety will not seem excessive when it is remembered that the stitch strength was determined from tests on new materials under conditions free from vibration and other influences which might tend to impair strength. Because of the impossibility of accurately measuring or estimating the amount of deterioration which will occur, it is well to provide an adequate reserve.

Since the maximum pressure for which the cover in the above example is designed occurs at 12 percent of the chord and tapers off aft of this point, it is obvious that the stitch spacing of $1\frac{1}{4}$ in. need not be used over the whole chord. On the other hand, it is not practicable to adjust each stitch spacing to correspond to the theoretical pressure. It is recommended that the stitch spacing for the peak pressure be applied back to the point where the theoretical pressure is approximately one-half the peak pressure for the wing. In the present example, one-half the peak pressure is 2.125 lb. per sq. in. and occurs at about 43 percent of the chord as shown in Fig. 10. The stitch spacing from this point aft to the trailing edge may then be doubled, becoming $2\frac{1}{2}$ in. In order to simplify work in the shops, it may be found convenient to use the closer stitch spacing over the whole distance between front and rear beams and use the double spacing aft of the rear beam. It is further recommended that the closer spacing be used over the whole of the chord in the slipstream area.

Summary of Recommended Practice for Covering

The condensed outline following, describing the most important details contributing to efficient covers and attachments, is presented to serve as a guide for both designers and shop personnel in checking process control. It is assumed that the engineering department will have calculated the design ultimate pressures and, from the results of actual pressure blow-off tests, specified the required stitch spacing. The engineering department should also investigate and provide detail instructions for all irregular features of assembly such as cut-outs for obstructions, anchorage of covers at wing root, inspection openings, drainage provisions, etc. The following practice has been proved by experience to provide uniform dependable covers:

(a) Preparation of Wing. Apply adhesive tape to all edges with radius less than 0.02 in. in contact with lacing or cover cloth.

(b) Application of Cover. Stretch the cover smooth but avoid any excessive straining. A tension of two pounds per running inch is ample to produce a taut drum-like surface after the doping has been applied. Excessive straining will shorten life of the material.

(c) Application of Anti-Tear Strip. If anti-tear strip is called for by the engineering department in order to provide required stitch strength, apply the anti-tear strip with very light tension and in a continuous length from trailing edge over top surface, around nose, and on bottom surface as far back as front beam. Apply anti-tear strip on wet dope.

(d) Application of Reinforcing Tape. Use tape of same width as capstrip, but never use tape that is wider than the capstrip. Apply in one continuous length from trailing edge, around nose, and back to trailing edge. Stretch the tape to about 10 lb. tension and tie free ends with pieces of lacing cord at trailing edge to hold tension. These ends and tie-off cord can be cut off after first coat of dope has dried.

(e) Awl Holes for Lacing. Mark off the position for the stitches carefully and accurately. Use a sharp awl of diameter not larger than the diameter of lacing needle. Punch the holes as near to the capstrip as may be possible and avoid mistakes that will necessitate the punching of more than one hole.

(f) Lacing Cord and Waxing. Use separate lengths of lacing cord approximately 10 ft. long. Hand wax each cord immediately before using it by passing it over a block of beeswax about six times. Do not use the end which has been passed through the eye of the needle.

(g) **Lacing.** Start lacing with double loop stitch at the most forward point and work aft with single loop stitches. Draw each stitch tight and tie-off with the type of knot shown in Fig. 8. For best strength, place the tie-off knots along the middle of bottom capstrip. Never pull these knots through the lacing holes. Join successive lengths of cord with a splice knot of the type shown in Fig. 9. Make finishing stitch with double loop or with double tie-off knot.

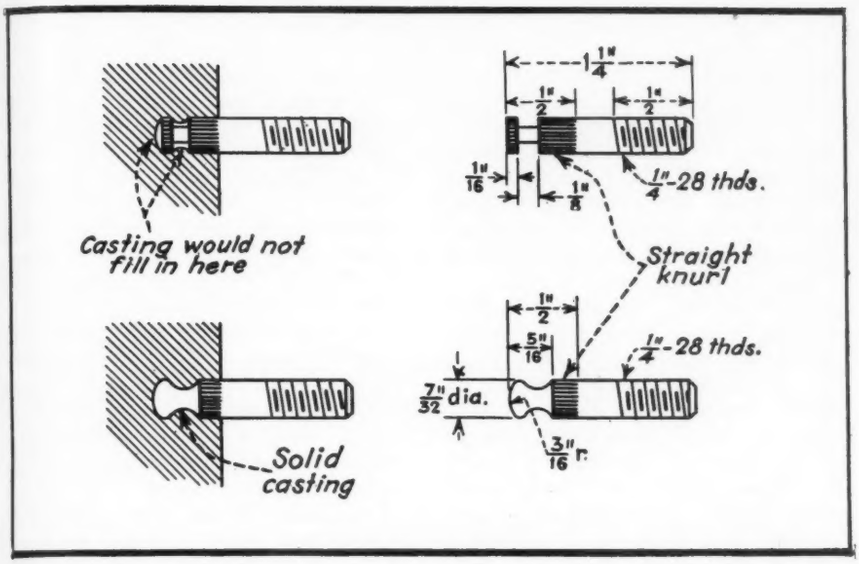
(h) Doping and Applying Finishing Tape. After lacing, cut off free ends of reinforcing tape at trailing edge. Apply second coat of clear dope and while this is wet, apply surface tape. Smooth down tape by brushing with wet dope. Apply remaining dope coats.

Caution: If sanding is used to increase smoothness of surface, sand very lightly over surface tape and never over lacing cords before application of surface tape.

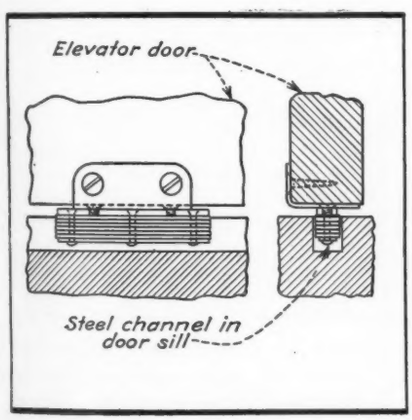
It cannot be over-emphasized that the most important single factor in the integrity of any wing covering is the care with which it is applied. The personnel performing this work should be highly skilled and each operation of the process should be carefully demonstrated to them. Such instruction, to be most effective, should include an explanation of the reason behind each detail, in addition to what to do and how to do it.

The foregoing discussion pertains particularly to only one type of fabric cover attachment, that is, the laced attachment. The information presented should enable manufacturers using this type of fastening to obtain 50 percent additional strength at no material increase in weight. However, there is much yet to be done. Unquestionably, higher strengths can be obtained, both from the use of improved materials and from new types of attachment. As more attention is turned to design, many new attaching methods other than lacing will be devised. For example, the cloth has been successfully secured by means of a wire clipped to the capstrip at intermittent points. Another design employs a grooved capstrip wherein the cloth is keyed into the groove. A modification of the present laced type is to drill the capstrip and lace the cover to it by the use of a curved needle. Self-tapping screws also have possibilities. All of these schemes must pass through the laboratory stage of development and then finally prove their worth by flight service. It is hoped that the description of the test methods and the outline of approach to the general problem as presented here may be of some assistance to those interested in the further development of high-efficiency fabric attachments.

Causes and Cures

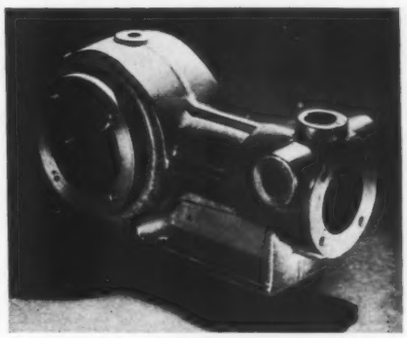


Aluminum alloy die-cast oil tank sump with cast-in studs was changed to a permanent mold casting to improve the welded joint with the aluminum oil tank. Failure soon occurred with the studs loosening when the nuts were drawn down tight. As no pressure is used on a permanent mold casting, the metal would not flow into the groove nor over the end of the stud. Redesigning the stud to induce metal flow solved the difficulty.



Sliding elevator doors are usually held in line by pins, rollers, or springs traveling in a channel in the doorway sill. When such devices fit neatly they cause a scratching noise and when they wear to a loose fit the door rattles and chatters. This problem has been solved by designing a door guide or gib made of layers of canvas duck sheets compressed together and bonded with synthetic rubber. Gib is fitted in threshold groove with 1/32 in. side clearance when new, and is riveted to steel bracket which is secured to the door.

Steel staples were specified for attaching the paper calibration slips to metal cylinders in bathroom scales. Ordinary flat-crown staples, made from a coil of wire in the automatic stapling machine used, were found to be satisfactory only for lighter gage cylinders. On larger cylinders, staples crumpled without penetrating. Cure was to use spring-crown staples. The curve in the crown tends to flatten out when staple is driven, forcing legs of staple outward against channels of machine to give legs firm lateral support.



Slight porosity in castings may lead to their rejection, but here is a cure for some cases. Pump casting shown above, on which machining costs had reached $15, had specifications which called for a 500 lb. per sq. in. water pressure. Tests revealed porosity at 100 lb. per sq. in. The casting was salvaged by impregnating with a new phenolic resin, after which it withstood 800 lb. per sq. in. without leakage.

DIFFICULT POINTS TO SEAL in an internal combustion engine are ends of crankshaft where they leave the crankcase. This problem is particularly difficult where seal must be split to facilitate assembly of engine. Leather and asbestos rope seals have been used, but they cannot be formed to exact shapes and contours as is required for a satisfactory seal. Cure was found with the development of synthetic rubber.

RIGID METAL PIPE handling potash brine at elevated temperatures often clogged with sharp potash crystals. To remove clogging, the maintenance crew had to tap the line with wooden mallets. This did not prevent accretion, and frequently the line had to be torn down and cleaned. Cure was to substitute rubber hose which vibrated when solution was pumped through the line.

A MOTOR DRIVING a lineshaft in a one-story frame building suddenly began to run very hot, without apparent cause. Shortly before there had been a severe snowstorm and it was found that the weight of the snow on the roof had thrown the lineshaft out of alignment.

PRODUCT ENGINEERING will pay a minimum of $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs.

ENDURANCE LIMIT

Its Importance in Determining Allowable Stress

H. W. HAMM

EXPERIENCE SHOWS THAT the ultimate strength of metals, which is usually the foundation for stress calculations, is subject to variations. Stresses other than tension, compression and bending, that is, shear and torsional stresses, show an ultimate stress different from the ultimate tensile strength. If in addition to such stresses a metal is subjected to changing loads or to impact, the ultimate strength is further reduced. The ultimate tensile strength, as found by tests in the tensile strength testing machine, therefore applies to only static and gradually applied loads. Tensile tests can be made conveniently. Also factors which reduce the ultimate strength can easily be expressed in fractions of ultimate tensile strength.

The cause for reduction of ultimate strength is assumed to be the fatigue of the metal. This fatigue causes permanent damage in the material. The reduction of ultimate strength through fatigue is called the endurance limit. Endurance limit is usually based on 500,000,000 cycles of completely reversed stress in the rotating beam fatigue machine.

The inverse value of the fraction of allowable stress and ultimate tensile strength is called the factor of safety. This term is misleading since the allowable stress often is the ultimate strength for certain applications. However, it is a convenient means of determining the allowable stress and for this reason is often used in specifications. Used without discrimination for all parts of a structure of a machine, it results in waste of material in some instances, and may be responsible for weakening of vital parts in others.

In order to eliminate the uncertainty of a conventional "factor of safety" and to arrive at an allowable stress which is in line with actual stress, it is necessary to classify the various causes for a reduction of ultimate strength from the ultimate strength as found by tensile strength testing machines, and from the endurance limit as found by the rotating beam method.

In each class representing a cause for reduction of ultimate strength it is necessary to establish the ratio of reduction for the various metals. Not always is it possible to rely on tests in this respect. Fatigue tests and notch resistance tests are missing in many instances, as well as data for various load applications. For this reason the designer is often forced to accept arbitrary safety factors which have been found satisfactory under circumstances only resembling his particular problem.

In determining the allowable stress it must be kept in mind that the assumed loadings in engineering calculations do not always represent the actual conditions. If design calculations are based on methods that are known to give only approximate results, it is necessary to reduce the allowable stress farther below ultimate tensile strength than when the design calculations are based on fairly exact methods.

An analysis of the variables that cause a reduction of allowable stress is always necessary. For each cause the fraction of reduction has to be established, and the final working stress will then he found by multiplication of all the fractions with the ultimate tensile strength.

The causes for reduction of working stress are:

1. Sudden instead of gradual application of load. The reduction is 50 percent.

2. The endurance limit, as found by the rotating beam method, applies to complete reversal of the load only. If the change of loading is less than that, the endurance limit is higher. For the latter the empirical formula by Howell may be used:

$$S = \frac{S_1 (r + 3)}{2}, \text{ in which}$$

S = Endurance limit for range stress

S_1 = Endurance limit as found by rotating beam method

$$r = \frac{\text{Min. stress}}{\text{Max. stress}}$$

When the endurance limit is not known it is safe to assume the following for ferrous alloys: 45 percent of ultimate tensile strength for wrought metals, 40 percent of ultimate tensile strength for cast metals. For nonferrous metals and alloys the endurance limit is usually lower.

4. The endurance limit as found by the rotating beam method applies to tension, compression and bending. For shear and torsional stresses it is much lower. When the load is static or nearly static it may come close to the endurance limit for flexural stresses. For complete reversal of stresses, however, it often approximates 50 percent of the endurance limit for bending.

5. Notch-resistance. The endurance limit for sections with abrupt changes in area, such as keyways, oil grooves, rivet holes, bolt holes, and threads is lower than for sections without such abrupt changes. The reason for this is that stress concentrations take place in sharp corners and in places where sudden changes of section occur. When the reduction of allowable stress from this cause is of vital significance, the reduction factor can be found by the photoelastic method; otherwise notch-resistance may be found from the notched bar tests, the results of which are given in the following table for five metals.

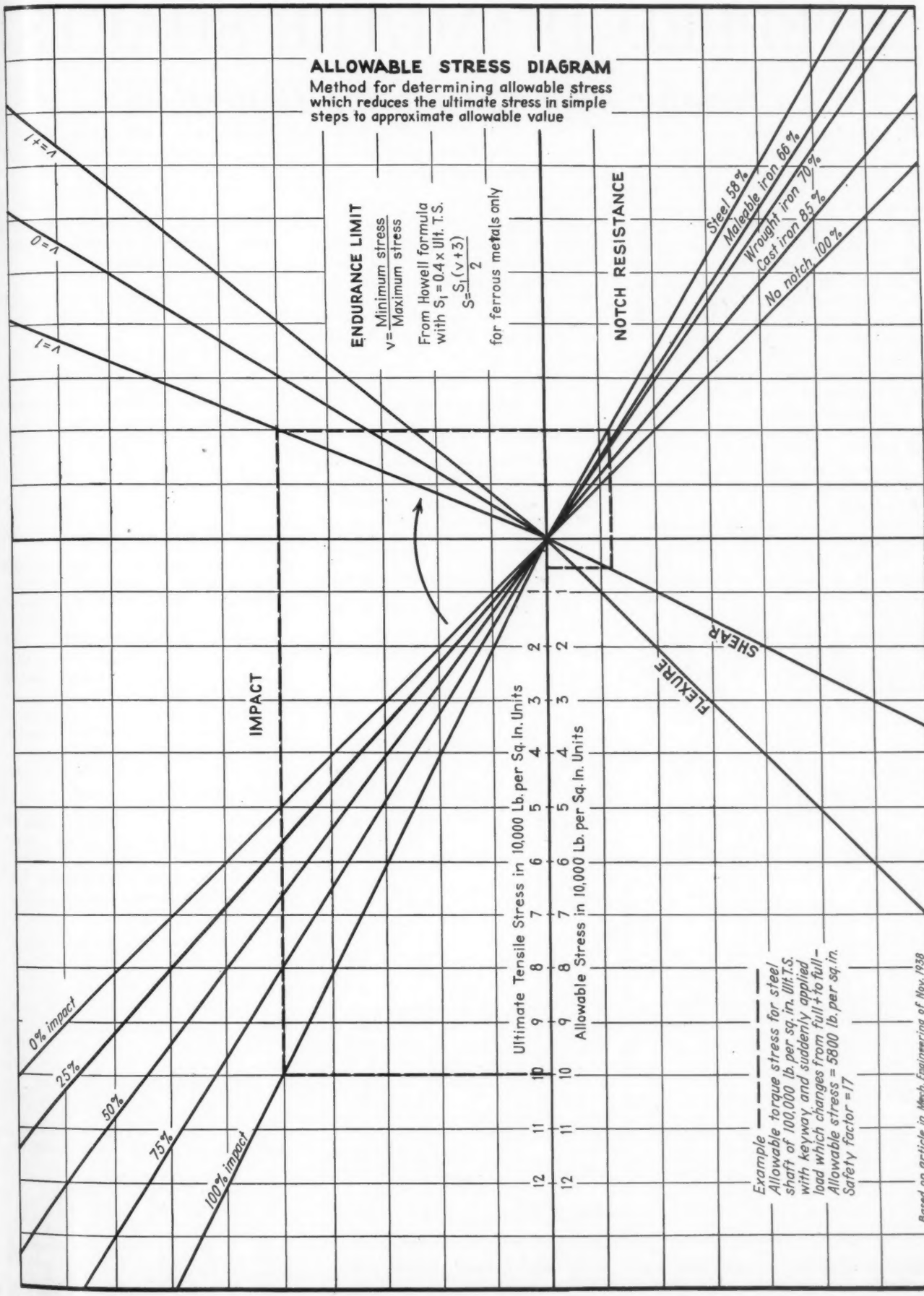
$$\text{Notch resistance} = \frac{\text{End. Limit for Notched Bar}}{\text{End. Limit for Smooth Bar}}$$

NOTCH RESISTANCE

Metal	*Resistance*
Cast Iron	0.85
Malleable Iron	0.66
Copper	0.66
Wrought Iron	0.70
Steel	0.58

CONCLUSION: For all practical purposes the allowable stress can be determined by the four reduction factors indicated on the chart shown on next page. These reduction factors do not apply where deflection, protection against vibration, or safety of columns are the determining factors for the size of a part or structure. In design calculations for these applications stress does not appear at all and modulus of elasticity is the determining factor.

REFERENCES: Kent, Mechanical Engineers Handbook, Edition 1938, Vol. 3. Structural Aluminum Handbook, Aluminum Co. of America, Ed. 1938. *Mechanical Engineering*, November 1938, p. 813 etc.


ALLOWABLE STRESS DIAGRAM
Method for determining allowable stress which reduces the ultimate stress in simple steps to approximate allowable value
ENDURANCE LIMIT
v = Minimum stress / Maximum stress
From Howell formula with $S_1 = 0.4 \times$ Ult. T.S.
$S = \frac{S_1(v+3)}{2}$
for ferrous metals only
NOTCH RESISTANCE
Steel 58%
Malleable iron 66%
Wrought iron 70%
Cast iron 85%
No notch 100%
SHEAR
FLEXURE
IMPACT
v=1
0=1
1=1
0% impact
25%
50%
75%
100% impact
Ultimate Tensile Stress in 10,000 Lb. per Sq. In. Units
Allowable Stress in 10,000 Lb. per Sq. In. Units
Example
Allowable torque stress for steel shaft of 100,000 lb. per sq. in. Ult. T.S. with keyway and suddenly applied load which changes from full + to full − Allowable stress = 5800 lb. per sq. in. Safety factor = 17
Based on article in Mech. Engineering of Nov. 1938

STEPPED-DIAMETER SHAFTS

Procedures for Calculating Deflections

A. F. PUCHSTEIN
Consulting Engineer

IN DESIGN PROBLEMS dealing with the deflection of shafts having stepped diameters that carry one or more loads, it is frequently desirable to check the result obtained by one method of calculation with the result obtained by another method. In this article three methods are set forth. Methods involving graphical integration and mechanical integrators are not included.

The degree of accuracy in the results as obtained by the methods outlined is affected by several sources of error:

1. Loads not known exactly.
2. Stiffening effect of hubs, collars and bearings.
3. Slide rule, numerical and graphical errors.
4. Modulus of elasticity not exactly known or it may be non-constant because of time-yielding characteristics.
5. Errors in basic mathematical assumptions. Examples of these are the yield at shearing surfaces; sections short enough so they no longer behave as of infinite length; and the common practice of replacing the expression

$$\frac{\frac{d^2y}{dx^2}}{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}} \text{ by } \frac{d^2y}{dx^2}$$

in the equation for the reciprocal of radius of curvature. This approximation makes the solution more wieldy, but restricts its application to small deflections such as are customarily allowed in machinery or buildings. The error introduced by this last factor becomes progressively greater as the deflection increases.

PROCEDURE 1

Differential Equation of Deflection

y = deflection measured in in. from some reference line, as the x-axis
x = distance in in. from some point selected as origin on the x-axis
M = bending moment in lb.in. at any point x
E = Young's modulus of elasticity, in lb. per sq.in.
I = rectangular moment of inertia in in.^{4} at point considered
d = diameter in in. of shaft at point considered

Differential equation for deflection is

$$\frac{d^2y}{dx^2} = \frac{M}{EI} \tag{1}$$

A set of coordinate axes is chosen usually in such a way that M and I can be expressed as functions of one axis, most commonly the x axis. This choice can often be made in different ways, some of which lead to shorter work than others. Integrating Equation (1) gives the slope at any point.

$$\int \frac{d^2y}{dx^2} = \frac{dy}{dx} = \int \frac{M}{EI} = \left(\frac{M_n}{E I_n}\right) dx + C_1 \tag{2}$$

and a second integration gives the corresponding deflection

$$\int\int \frac{d^2y}{dx^2} = \int\int \frac{M}{EI} = \left(\frac{M_n}{E I_n}\right) dx^2 + C_1 x + C_2 \tag{3}$$

Note the significance of the constants of integration. C_1 represents the slope of the elastic curve and C_2 the value of y at the beginning of any section. A section here is defined as being a part of the shaft between any two critical points such as those at the neck, load or bearing. To obtain a solution Equations (2) and (3) are applied successively to each section, starting at any point as origin, and working toward the ends. This method is fundamental but requires some skill.

EXAMPLE A. To find the deflections of the shaft shown in Fig. 1, the coordinates x and y are chosen as indicated. Then, at any point x the bending moment in lb.in.

$$M = \frac{P}{2}\left(\frac{l}{2} - x\right) \tag{4}$$

from Equations (2) and (3)

$$\frac{dy}{dx} = \frac{P}{2 E I_n}\left(\frac{l}{2}x - \frac{x^2}{2}\right) + C_1 \tag{5}$$

$$y = \frac{P}{2 E I_n}\left(\frac{l}{4}x^2 - \frac{x^3}{6}\right) + C_1 x + C_2 \tag{6}$$

The moments of inertia for shaft sections (1), (2), and (3) are respectively

$I_1 = 0.0491 \times 1^4 = 0.0491$ in.^{4}
$I_2 = 0.0491 \times 0.75^4 = 0.0155$ in.^{4}
$I_3 = 0.0491 \times 0.5^4 = 0.00307$ in.^{4}

then taking E as 3×10^7 for steel

$EI_1 = 1.47 \times 10^6$
$EI_2 = 4.65 \times 10^5$
$EI_3 = 9.21 \times 10^4$

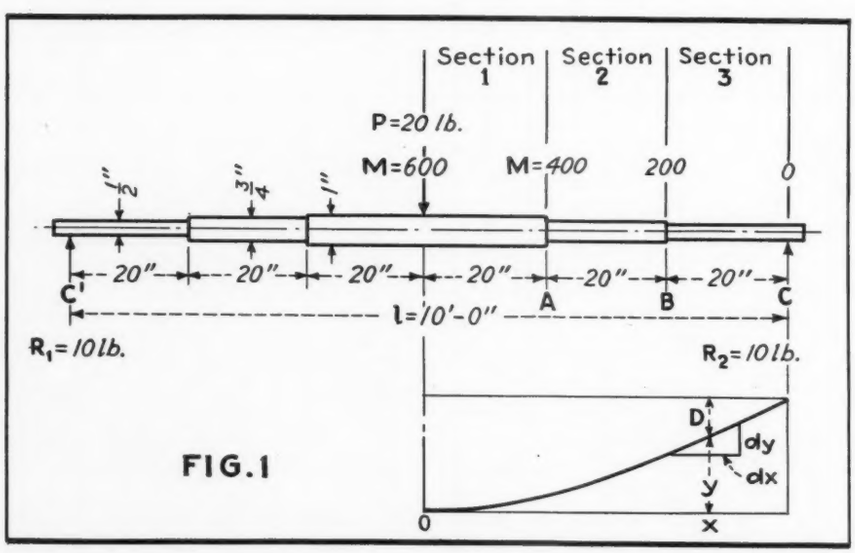


FIG. 1

Fig. 1—Stepped-diameter shaft with load at center and supported at ends showing method of choosing origin and coordinates to define the elastic curve

For Section (1) where shaft dia. is 1 in.

From Equation (5)

$$\frac{dy}{dx} = \frac{600x - 5x^2}{1.47 \times 10^6} + C_1 \quad (7)$$

Since shaft dimensions and loading are symmetrical about the y axis, $dy/dx = 0$ when $x = 0$, so that $C_1 = 0$

From Equation (6)

$$y_1 = \frac{300x^2 - 1.67x^3}{1.47 \times 10^6} + C_2 \quad (8)$$

Also $y_1 = 0$ when $x = 0$, so that $C_2 = 0$

Equations (7) and (8) give slope and deflection for any point between $x = 0$ and $x = 20$ in. At A where $x = 20$ in.

$$\frac{dy}{dx} = \frac{600 \times 20 - 5 \times 20^2}{1.47 \times 10^6} = 0.00680 \quad (9)$$

$$y_1 = \frac{300 \times 20^2 - 1.67 \times 20^3}{1.47 \times 10^6} = 0.0726 \text{ in.} \quad (10)$$

For Section (2) where shaft dia. is ¾ in.

The same procedure is repeated but new values for C_1 and C_2 are found. Thus, when $x = 20$ in., $y = 0.0726$ in. and from Equations (5) and (6),

$$C_1 = 0.0068 - \frac{600 \times 20 - 5 + 20^2}{4.65 \times 10^5} = -0.0147 \quad (11)$$

$$C_2 = 0.0726 + 0.0147 \times 20 - \frac{300 \times 20^2 - 1.67 \times 20^3}{4.65 \times 10^5} = 0.137 \text{ in.} \quad (12)$$

Applying Equations (5) and (6) for $x = 20$ in. to 40 in. At B where $x = 40$ in.

$$\frac{dy}{dx} = \frac{600 \times 40 - 5 \times 40^2}{4.65 \times 10^5} - 0.0147 = 0.0197 \quad (13)$$

$$y = \frac{300 \times 40^2 - 167 \times 40^3}{4.65 \times 10^5} - 0.0147 \times 40 + 0.137 = 0.352 \text{ in.} \quad (14)$$

For Section (3) where shaft dia. is ½ in.

The work is again repeated, thus when $x = 40$ in., $y = 0.352$ in. and the

$$\text{slope } \frac{dy}{dx} = 0.0197$$

then from Equations (5) and (6)

$$C_1 = 0.0197 - \frac{600 \times 40 - 5 \times 40^2}{9.21 \times 10^4} - = 0.154 \quad (15)$$

$$C_2 = 0.352 + 0.154 \times 40 - \frac{300 \times 40^2 - 1.67 \times 40^3}{9.21 \times 10^4} = 2.47 \text{ in.} \quad (16)$$

At C where $x = 60$ in.

$$\frac{dy}{dx} = \frac{600 \times 60 - 5 \times 60^2}{9.21 \times 10^4} - 0.154 = 0.0414 \quad (17)$$

$$y = \frac{300 \times 60^2 - 1.67 \times 60^3}{9.21 \times 10^4} - 0.154 \times 60 + 2.47 = 1.03 \text{ in.} \quad (18)$$

The deflections D from a center line through the bearings C′, C, then are

at O, $D = 1.03$ in.
at A, $D = 1.03 - 0.0726 = 0.96$ in.
at B, $D = 1.03 - 0.32 = 0.68$ in.

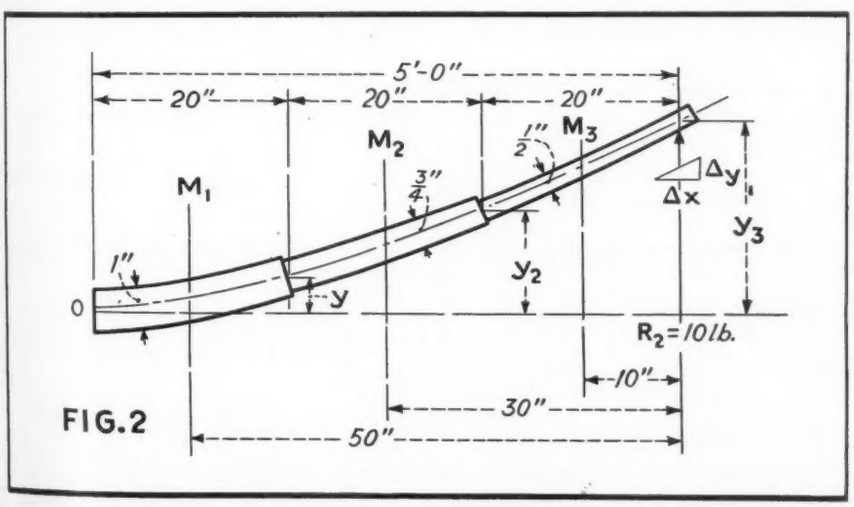


FIG. 2

Fig. 2—Right-hand half of stepped-diameter shaft shown in Fig. 1 to illustrate method of computing average bending moments in the three sections

PROCEDURE 2

Alternate Process for Differential Equation Method

The steps as described in Procedure 1 can be carried out easier by a slightly different procedure, particularly for multiple loads and overhanging ends. Let M_1 and M_2 be the bending moments at the beginning and end of any section n, and x_1 and x_2 the corresponding values of x, then the slope and deflection at the end of the section considered are given by

$$\frac{dy}{dx} = \left(\frac{M_1 + M_2}{2}\right)\left(\frac{x_2 - x_1}{E\,I_n}\right) + C_{1(n-1)} \quad (19)$$

and

$$y = \left(\frac{2M_1 + M_2}{6}\right)\left[\frac{(x_2 - x_1)^2}{E\,I_n}\right] + C_{1\,(n-1)}\,(x_2 - x_1) + C_{2\,(n-1)} \quad (20)$$

The work is started by assuming some point along the shaft as horizontal where $C_{1(n-1)} = 0$, $C_{2(n-1)} = 0$ and working toward the ends. The distance x in either direction from 0 may be taken as positive.

EXAMPLE: For shaft shown in Fig. 1.

For Section (1), where dia. is 1 in., $x_1 = 0$ in. and $x_2 = 20$ in.

Equations (19) and (2) give

$$\frac{dy}{dx} = \left(\frac{600 + 400}{2}\right)\left(\frac{20 - 0}{1.47 \times 10^6}\right) = 0.00680 = C_1$$

$$y = \left(\frac{1200 + 400}{6}\right)\left[\frac{(20 - 0)^2}{1.47 \times 10^6}\right] = 0.0726 \text{ in.} = C_2$$

For Section (2) where the dia. is ¾ in. $x_1 = 20$ in. and $x_2 = 40$ in.

$$\frac{dy}{dx} = \left(\frac{400 + 200}{2}\right)\left(\frac{40 - 20}{4.65 \times 10^5}\right) + 0.00680 = 0.0197 = C_1$$

$$y = \left(\frac{800 + 200}{6}\right)\left[\frac{(40 - 20)^2}{4.65 + 10^5}\right] + 0.0068 \times (40 - 20) + 0.0726 = 0.352 \text{ in.} = C_2$$

For Section (3), where the dia. is ½ in., $x_1 = 40$ in. and $x_2 = 60$ in.

$$\frac{dy}{dx} = \left(\frac{200 + 0}{2}\right)\left(\frac{60 - 40}{9.21 \times 10^4}\right) + 0.0197 = 0.0414 = C_1$$

$$y = \left(\frac{400 + 0}{6}\right)\left[\frac{(60 - 40)^2}{9.12 \times 10^4}\right] + 0.0197 \times (60 - 40) + 0.352 = 1.03 \text{ in.}$$

Deflections at intermediate points are

Table I—Calculations and Results by Morley's Method

(1) Point, Fig. 3	(2) Step Δx In.	(3) Distance x In.	(6) Shear	(7) ΔM = (2) × (6)	(8a) $M = \Sigma_o^x \Delta M$	(9) $\frac{I_o}{I} = \left(\frac{d_o}{d}\right)^4$	(10a) $M_1\left(\frac{I_o}{I}\right)$	(10b) $M_2\left(\frac{I_o}{I}\right)$	(11a) $= \Delta A_1 = \frac{\Delta x}{2}$ (10a)	(11b) $= \Delta A_2 = \frac{\Delta x}{2}$ (10b)
D	20	20	−13.33	−267	−267	1.0	0	−267	0	−2,667
E	10	30	−13.33	−133	−400	0.198	− 53.0	− 79.3	− 264	− 396
F	10	40	− 3.33	− 33.3	−433	0.198	− 79.3	− 85.6	− 396	− 429
G	20	60	− 3.33	− 66.7	−500	0.0625	− 27.1	− 31.2	− 271	− 312
H	20	80	6.67	133	−367	0.0625	− 31.2	− 22.9	− 312	− 229
C	10	90	6.67	66.7	−300	0.198	− 72.5	− 59.4	− 363	− 297
I	10	100	6.67	66.7	−233	0.198	− 59.4	− 46.2	− 297	− 230
J	10	110	6.67	66.7	−167	1.0	− 23.3	− 16.7	−1,167	− 833
B	10	120	16.67	167	0	1.0	−167	0	− 833	0

(1) Point, Fig. 3	(12) $= \Delta A$ = (11a) + (11b)	(13) $= \Sigma_o^x \Delta A$	(14a) $= \bar{x}_1$	(14b) $= \bar{x}_2$	(15a) $= \bar{x}_1 . \Delta A_1$ = (11a) × (14a)	(15b) $= \bar{x}_2 . \Delta A_2$ = (11b) × (14b)	(16) $= x . \Delta A$ = (15a) + (15b)	(17) $= \Sigma_o^x x . \Delta A$
D	−2,667	−2,667	$0 + \frac{1}{3}.0$	$0 + \frac{2}{3}\overline{DE}$	0	−35,600	− 35,600	− 35,600
E	− 660	−3,327	23.33	26.67	− 6,150	−10,600	− 16,750	− 52,300
F	− 825	−4,152	33.33	36.67	− 13,200	−15,700	− 28,900	− 81,200
G	− 583	−4,735	46.67	53.33	− 12,500	−16,600	− 29,100	−110,300
H	− 541	−5,276	66.67	73.33	− 20,800	−16,800	− 37,600	−147,900
C	− 660	−5,396	83.33	86.67	− 30,200	−25,800	− 56,000	−203,900
I	− 527	−6,463	93.33	96.67	− 27,700	−22,200	− 49,900	−253,800
J	−2,000	−8,463	103.33	106.67	−121,000	−89,000	−210,000	−463,800
B	− 833	−9,296	113.33	.....	− 94,500	0	− 94,500	−558,300

given in the same way; it is merely necessary to sub-divide the shaft length to match. Actual deflections *D* are then found as in the previous procedure.

PROCEDURE 3

Finite Difference or Step by Step Method

This method is useful where the integrations necessary in Procedure 1 are inconvenient, where Procedure 2 can not be applied as for tapered sections, or where only approximate results are desired. The finite difference method is based on the formulas

$$\left(\frac{\Delta y}{\Delta x}\right)_n = \frac{M_n}{E I_n} + C_{1\,(n-1)} \qquad (21)$$

$$y_n = \left(\frac{\Delta y}{\Delta x}\right)_n (\Delta x) + C_{2\,(n-1)} \qquad (22)$$

EXAMPLE: For the shaft shown in Figs. 1 and 2 the average bending moments in the three sections are

$M_1 = 10 \times 50 = 500$ lb.in.
$M_2 = 10 \times 30 = 300$ lb.in.
$M_3 = 10 \times 10 = 100$ lb.in.

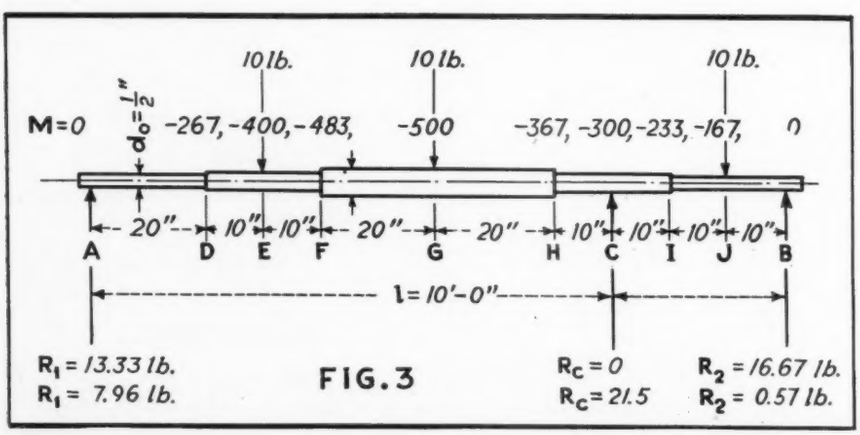


Fig. 3—Sketch of shaft with loads and bearings showing method of lettering loads, bearings and changes of diameter for tabulation used in Morley's method

the constants C_1 and C_2 are both taken as zero at $x = 0$.

For Section 1

$$\left(\frac{\Delta y}{\Delta x}\right)_1 = \frac{M_1}{E I_1}(x_2 - x_1)_1 + C_{10}$$

$$= \frac{500}{1.47 \times 10^6} \times (20 - 0) + 0$$

$$= 0.00680$$

$$y_1 = \left(\frac{\Delta y}{\Delta x}\right)_1 (x_2 - x_1) + C_{20}$$

$$= 0.00680 \times (20 - 0) + 0 = 0.136 \text{ in.}$$

For Section 2

$$\left(\frac{\Delta y}{\Delta x}\right)_2 = \frac{M_2}{E I_2}(x_2 - x_1)_2 + C_{11}$$

$$= \frac{300}{4.65 \times 10^6} \times (40 - 20) + 0.00680$$

$$= 0.0197$$

$$y_2 = 0.0197 \times (40 - 20)_2 + 0.136 = 0.530 \text{ in.}$$

For Section 3

$$\left(\frac{\Delta y}{\Delta x}\right)_3 = \frac{M_3}{E I_3}(x_2 - x_1)_3 + C_{12}$$

$$= \frac{100}{9.21 \times 10^4} \times (60 - 40) + 0.0197$$

$$= 0.0414$$

$$y_3 = 0.0414 \times (60 - 40)_3 + 0.530 = 1.35 \text{ in.}$$

For accuracy, a greater number of steps should be used. Deflections at in-

termediate points are found by interpolation or by selecting the lengths of sections to coincide. Multiple loads are handled in the same way. For unsymmetrical shaft or loading, place the origin 0 at any convenient point and work toward each end. Overhanging loads introduce no new problems. Many other approximate processes are possible.

PROCEDURE 4

Morley's Method

This method employs a tabular integration which does not require the thought processes of higher mathematics, but does require care and accuracy in the numerical work. The procedure is essentially the same for 2 or 3 bearings with any number of loads in any location, any number of shaft diameters or one diameter only, with or without overhanging loads. Shaft weights and other distributed loads are omitted in all the examples. In simple cases, Procedures 1 and 2 are easier to apply.

Symbols and Procedure

I—Draw sketch of shaft with loads and bearings as shown in Fig. 3. Letter each load, bearing, shaft neck and all intermediate points at which calculated values are desired. Write in loads and shaft dimensions. It helps to avoid errors if a shear diagram is drawn; this need not be to scale.

II—Make table similar to Table I with column headings respectively as follows. Use sufficient significant figures, though the slide rule is permissible in many cases.

(1) Lettered points as shown
(2) Length increments $\triangle x$ in in.
(3) Distance from left $x = \Sigma_o^x \triangle$ in in.
(4) Sign and location of each load W_n in. lb.
(5) Moment of each load about left end $x\ W_n$ = Col. (3) × Col. (4) lb.in.
(6) Shear in section at left of letter in Col. 1 (see Fig. 4) in lb.

Table II—Slopes and Deflections at Critical Points

Point	$\frac{dy}{dx}$	y	Point	$\frac{dy}{dx}$	y
G	Assume = 0	Assume = 0	H	0.0059	0.0620
F	0.00635	0.0650	C	0.0131	0.155
E	0.0153	0.174	I	0.0188	0.319
D	0.02215	0.365	J	0.0405	0.621
A	0.0515	1.201	B	0.0496	1.086

(7) Bending moment increments $\triangle M$ = Col. (2) × Col. (6) in lb. in.
(8a) Bending moments $M = \Sigma_o^x \triangle M$ = summation of values in Col. 7 (see Fig. 4) in lb. in.
(8b) Shaft diameter at left of letter in Col. 1
(9) $\frac{I_o}{I} = \left(\frac{d_o}{d}\right)^4$, d_o = diameter of section AB, d = diameter of any other section
(10a) $M_1\left(\frac{I_o}{I}\right)$ = Col. (8a_1) × Col. (9), M_1 = bending moment at left end of section considered = M at preceding letter.
(10b) $M_2\left(\frac{I_o}{I}\right)$ = Col. (8a_2) × Col. (9), M_2 = bending moment at right end of section considered = M at same letter
(11a) Col. (10a) × $\frac{\triangle x}{2}$, denoted by $\triangle A_1$, in lb. in.
(11b) Col. (10b) × $\frac{\triangle x}{2}$, denoted by $\triangle A_2$, in lb. in.
(12) Col. (11a) + Col. (11b), denoted by $\triangle A$, in lb. in.
(13) Summation of values from Col. 12 = $\Sigma_o^x \triangle A$, in lb. in.
(14a) Distance $\bar{x}_1 = x + 1/3 \times \triangle x$, Fig. 5, in in.
(14b) Distance $\bar{x}_2 = x + 2/3 \times \triangle x$, Fig. 5, in in.

In Fig. 5, S represents any letter in Col. 1 and x is the value from Col. 3 at the previous letter; $\triangle x$ is the distance between.

(15a) Col. (11a) × Col. (14a), denoted by $\bar{x}_1 \times \triangle A_1$, in lb. in.
(15b) Col. (11b) × Col. (14b), denoted by $\bar{x}_2 \times \triangle A_2$, in lb. in.
(16) Col. (15a) + Col. (15b), denoted by $x \times \triangle A$, in lb. in.
(17) Summations from Col. 16 = $\Sigma_o^x x \times \triangle A$, in lb. in.

l = distance between outer bearings, outer loads or outer load and outer bearing, whichever is the greater, in in.

Deflection at any letter, at distance x from left

$$y = \frac{1}{E\,I_o}\left\{x\left[\frac{1}{l}\sum_o^l x \times \Delta A - \sum_o^i \Delta A + \sum_o^x \Delta A\right] - \sum_o^x x \times \Delta A\right\}$$

$$= \frac{1}{E\,I_o}\left\{x\left[\left(\frac{\text{Bottom line of Col. 17}}{l}\right) - \left(\begin{matrix}\text{Bottom line}\\ \text{of Col. 13}\end{matrix}\right) + \left(\begin{matrix}\text{Col. 13}\\ \text{at } x\end{matrix}\right)\right] - \left(\begin{matrix}\text{Col. 17}\\ \text{at } x\end{matrix}\right)\right\} \quad (23)$$

y = deflection from center line through bearings, when no loads overhang; otherwise, it is as shown in Fig. 6, the deflection from a reference line through the beginning and end bearing or load points of the shaft.

EXAMPLE: For a more elaborate illustration, take Fig. 3 with two bearings, A and B. Find reactions and bending moments. Using a 10-in. slide rule and taking origin at G, the results by Procedure 2 are indicated in Table II. A

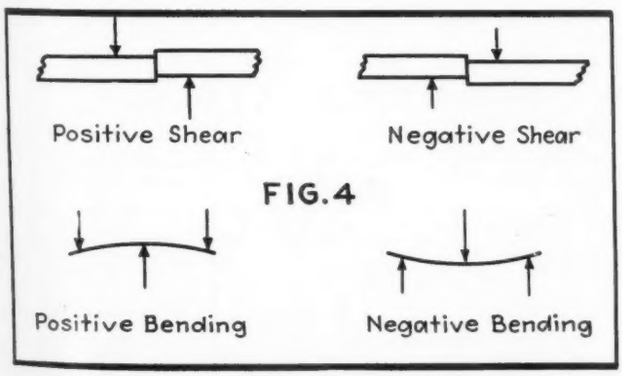


Fig. 4—Diagrammatic sketch to illustrate positive and negative shear and positive and negative bending in a simply supported shaft

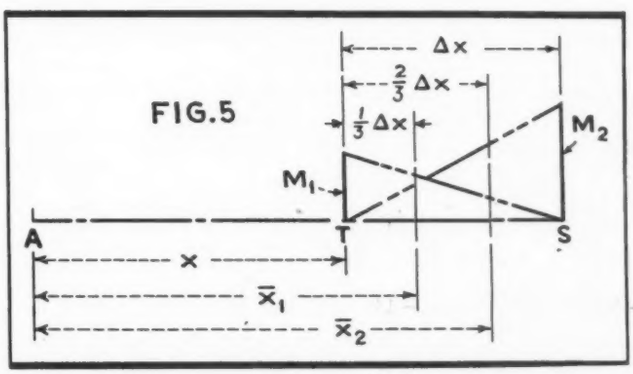


Fig. 5—Scheme for dividing a shaft section between critical planes for calculating by Morley's method the conditions existing at intermediate points

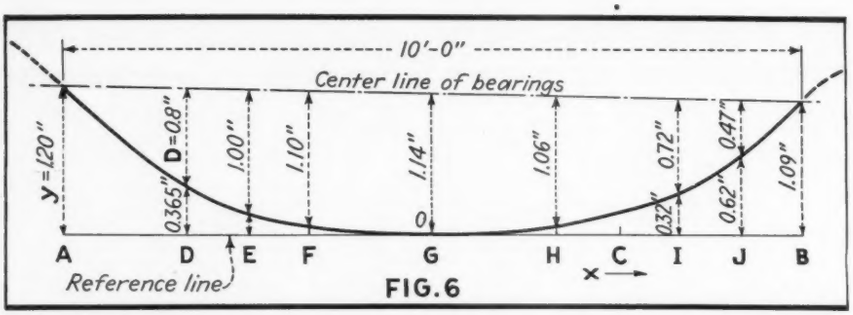


FIG.6

Fig. 6—Deflections with respect to the center line of bearings for stepped-diameter shafts with overhanging end loads

letter is placed at each change in diameter, each load and each bearing. If values are wanted at some intermediate point, a letter is placed there also.

Deflection from center line through bearings

$$D_G = \frac{1.201 + 1.086}{2} = 1.14 \text{ in.}$$

Deflections are given in Fig. 6 for other points.

By Morley's process the work is as indicated in Table I. Cols. 4 and 5 are omitted from this table. The other columns are not renumbered. Point *C* is added because for a condition which will later be introduced a third bearing is to be placed there.

Bearing reactions, $R_1 = 13.33$ lb., $R_2 = 16.67$ lb.

By Equation (23), deflection at any letter, as *G*

$$D_G = y_G = \frac{10^{-4}}{9.21} \times \left\{60\left[\frac{558.300}{120} + 9{,}293 - 4{,}646\right] + 110{,}300\right\} = 1.18 \text{ in.}$$

Reaction of Third Bearing and Deflections

When a third bearing is present, as at *C*, a load R_C is assumed at that point, with all other loads removed. Reactions, $R_1 = 0.25\ R_C$ and $R_2 = 0.75\ R_C$, are next obtained, and the work indicated in Table I is repeated. This gives for the deflection at *C* caused by "load" R_C alone.

$$D_C = y_C = \frac{R_C}{9.21 \times 10^4} \times \left\{90\left[\frac{-27{,}021}{120} + 346.2 - 159.1\right] + 7{,}501\right\}$$

$$= \frac{0.409}{9.21} R_C = 0.0445\ R_C$$

The reaction R_C is taken as the load at *C* which gives a deflection at *C* equal to that caused by the other loads with two bearings, thus

$$D_C = 0.0445\ R_C = 0.955 \text{ in.}$$

from which $R_C = 21.5$ lb. and

$$R_1 = 13.33 - 21.5 \times \frac{30}{120} = 7.96 \text{ lb}$$

$$R_2 = 16.67 - 21.5 \times \frac{90}{120} = 0.57 \text{ lb.}$$

The values given in Table III are for shaft deflections with 2 and 3 bearings.

When Loading and Shaft Are Unsymmetrical

All procedures apply without change. With Procedures 1, 2 and 3 it is merely necessary to assume the slope of the elastic curve at some point 0, Fig. 6, as horizontal and then to work toward both ends in the regular way.

When Overhanging End Loads Are Present

All procedures given apply without change. The work is carried beyond the confines of the bearings as shown by the dotted lines in Fig. 6. With Procedure 4 the first entry in Table I is again the first section from the left end. Distance *l* is taken as the length over all sections, including overhang. Equation (23) gives the deflections *y* from a line of reference. The values of *y* for the two outer loads—or an outer load—and a bearing point (if one end only overhangs) will be zero; this reference line passes through these two points. The actual deflections *D* with respect to a center line through the bearings are then found as indicated in Fig. 6. The effect of the third bearing is calculated as outlined in connection with Table III, in precisely the same way.

Distributed Loads and Tapered Shafts

When the necessary integrations in Procedure I are feasible, theoretically exact solutions may be developed for distributed loads, tapered shafts, or combinations. For the purposes of this article it is sufficient to replace the distributed loads by an appropriate number of equivalent concentrated loads, and each smoothly tapered part by several stepped parts; then proceed in the regular manner.

Loads in Different Planes

When these planes lie at right angles to the center line through the bearings, it is the more convenient to resolve each load into its horizontal and vertical components. The deflections are then computed separately for the horizontal and vertical planes, when the actual deflection at any point *x*, and its direction are given by

$$D_x = \sqrt{D_h^2 + D_v^2}$$

$$\theta_x = \tan^{-1}\frac{D_v}{D_h}$$

This article gives a group of methods for calculating deflections when two or three rigid bearings are present. These are arranged to give the results with the least possible effort. Procedure 2 will be best for most purposes. Procedure 1 requires skill and care to avoid complication. Procedure 3 is most suitable for quick approximate work. Procedure 4 is versatile, but requires care and considerable accuracy in computation.

Table III—Deflections With 2 and 3 Bearings

Point	Caused by Loads Alone	Caused by 21.5 lb. at *C* Alone	Caused by Loads with 3 Bearings
D	0.816	−0.480	0.336
E	1.02	−0.645	0.375
F	1.12	−0.760	0.360
G	1.18	−0.922	0.258
H	1.06	−0.995	0.075
C	0.955	−0.955	0
I	0.785	−0.825	−0.040
J	0.478	−0.505	−0.023
B	0	0	0

HYDRAULIC SYSTEMS

Design and Maintenance

HYDRAULIC SYSTEM cleanliness cannot be over-emphasized. A large proportion of hydraulic system troubles are traceable to maintenance failure in this respect. Consideration of the design, assembly, and shop maintenance of hydraulic systems is based on the necessity for oil cleanliness in obtaining satisfactory operation. Dirt may consist of foreign particles remaining after fabrication or repairs, or contained in the atmosphere and oil, or may be the result of oil deterioration because of excess heat, presence of air, or both.

In the following specifications, covering features in the design of hydraulic systems, the precautions to be observed are largely out of consideration for the possibility of oil contamination.

Oil Reservoirs

CAPACITY. Selecting a reservoir of sufficient capacity is essentially a problem of obtaining the required differential plus a reasonable amount for reserve. Additional capacity is advantageous for natural radiation, to avoid emulsion, and for better settling of foreign matter.

BAFFLING. It is preferable to place a solid baffle plate between the suction and all discharge lines. This plate should extend above the highest oil level to hold the foam back. The opening for oil passage should be far enough from the bottom to make a settling chamber.

BREATHER. Specify a completely enclosed reservoir equipped with a breather so designed that chips, water, or other foreign material cannot get into the oil.

SUCTION LINE FILTER. When advisable to use a filter on the suction line specify adequate capacity and accessibility for cleaning. Periodic cleaning is necessary to prevent restriction of intake flow and resultant gasification of oil and noisy pump operation.

Some authorities advise against suction filters and favor use of an auxiliary filter unit handling only a portion of the oil independent of the main system. Renewable elements add to their convenience. Such elements ordinarily should be replaced after the first two weeks of operation and every three months thereafter.

PIPING CONNECTIONS. Specify location below oil level. This avoids emulsification which is especially important on large high-speed presses where a large volume of oil is being returned to the reservoir and large press rams are being raised at high speed. Place piping connections on the end of the reservoir opposite the pump suction so as not to interfere with the suction of a solid column of oil. Vent lines, scavenging lines and some drain connections, of course, are above oil level.

AUXILIARY SCAVENGER UNIT. When an auxiliary scavenger pump and drain sump are used, the reservoir intake connection should be above the high oil level when excessive air is present.

Scavenger units are employed on some hydraulic systems to lift oil from an auxiliary drain sump to the main reservoir. Since the volume of the scavenger pump is always greater than the amount of oil in the auxiliary sump, a large quantity of emulsified oil is always delivered to the reservoir.

Specifications for Assembling Piping

(1) Specify low carbon, cold drawn, seamless steel tubing with 1,200 deg. F. anneal for the most durable, leakproof, and trouble-free service. The anneal facilitates bending. If tubing is not to be bent, warehouse stock is suitable.

(2) Wrought iron pipe may be used if care is exercised in its selection. It must be free from seams, internal welds, zinc lining since serious damage to equipment has often resulted from loosened particles of scale or flakes of zinc.

(3) Specify sharp dies capable of making clean threads.

(4) Specify removal of all sharp edges or loose particles of metal after pipe threads are cut to prevent their getting into the line.

(5) Specify tight and leakproof screw joints without the use of any compound other than oil.

BRAZED JOINTS

(6) For leak-proof connections specify an arrangement of piping into sections of such length that they may be removed from the machine for brazing the threads at the fitting joints. Piping can then be positioned by the brazing operator to produce a natural flow of brazing metal.

(7) Specify brazing of screw joints between tubing and fittings after assembly.

(8) For brazing, Oil Gear recommends Oxweld rod No. 25M or equivalent.

(9) Specify precautions in brazing to avoid overheating or unequal expansion of metal. It has been demonstrated conclusively that improper brazing will crack the tubing at the root of the thread.

The flame should be directed against the fitting rather than against the wall of the tubing and heat should be applied slowly and evenly up to the point at which the rod will flow and alloy properly. Sufficient material to completely fill all exposed threads and produce a smooth fillet in the joint is used so that stress concentrations will be eliminated.

(10) On screwed joints that will not be brazed, a good way to assure perfect joints is to tin the pipe threads, then coat with clear lacquer. Never use shellac.

(11) Specify thorough wiping inside piping before final assembly to remove all dirt.

(12) Specify relief of all strain in fitting pipes and fittings into position.

FLARED JOINTS

(13) Specify a tubing which is dead soft and free of drawing marks.

(14) Specify straight, square and smooth cut tube ends for flaring.

(15) Specify a flaring tool approved by the fitting manufacturer and make the flare long enough for a good seal between fitting and nut. Overworking the flare

end, however, must be avoided since it has a tendency to harden the metal and make it subject to cracking in service.

(16) Forged steel fittings and nuts must be used with flared steel tubing. One type of fitting requires no flaring.

(17) In places where flanges are packed with copper gaskets, specify an anneal for the gaskets before reassembling after the connection has been broken.

(18) When welding fittings are used, specify removal of all scale formed in the tubing.

COPPER TUBING

Copper tubing is satisfactory in many applications for pressures up to 1,000 lb. per sq.in. when vibration is not excessive and it does not have to withstand hydraulic shocks. Destructive shock may be caused by rapid change of flow of oil or sudden relief of pressure. Vibration of a copper tube line will result in hardening and breakage.

(19) Specify dead soft tubing only.

(20) When extruded fittings are used, specify annealing before assembly.

(21) Starting the thread straight in making connections during assembly is important because damaged threads mean loose joints and loss of power.

(22) Specify a bending die that will not collapse the tube. Filling the tube with sand or low melting alloy is a simple way of bending tubing without collapsing the walls if no other tools are available.

(23) Avoid extremely sharp bends.

(24) Specify tubing supports wherever necessary to prevent vibration. Specify relief of strains after coupling tubing.

Inside cleanliness is as important as with steel tubing and thorough cleaning should precede installation. Similarly, flared ends should be prepared by filing smooth after cutting and the proper tool used to give a good seat.

(25) Specify brass fittings for flared copper tubing. To prevent fitting wall from distorting and causing annoying leaks, the tubing nut should be inserted before tightening the fitting in place.

STANDARD WELDED PIPE

(26) If standard welded pipe is used, specify pickling to remove all inside scale followed by thorough washing to remove the acid.

(27) Design piping sections suitable for brazing the threads at the fitting joint.

GENERAL RULES

(28) Turn pump shafts by hand when first starting pump after installation or when idle for a long period to be sure that working parts are free.

(29) Turn motor control off and on several times before allowing pump to reach full speed to make sure lubricating oil has reached closely fitted parts.

(30) Specify air breather vents or cleaners on reservoirs when large volume differentials are used or when air in the shop contains foreign particles that are detrimental in the fluid power system. If necessary, specify extension of breather connection to another department or outside the plant.

(31) Eliminate air traps when designing piping. Provide automatic air drain valves or petcocks for freeing air if necessary.

(32) Specify a minimum of sharp bends and the shortest possible length of piping in order to obtain highest possible efficiency of the system.

Hints On Oil and Cooling

Use oil of the right viscosity. Faulty lubrication caused by thin oil will be indicated by inability to develop and hold the desired pressure, overheating of the pump, or reduction in power output. Too heavy oil causes sluggish action. Lack of sufficient oil in the system is indicated by noisy operation and lack of positiveness in the drive due to the presence of air or gassified oil.

Excessive oil temperature is harmful to lubrication and must be prevented, especially when between bronze and steel, by providing for cooling the oil after it has passed through the pump and motor. Recommended practice is to regulate the cooling system so as to reduce the oil temperature to 130 deg. F.

Some systems develop less heat than others. The volumetric type of pump frequently has the advantage in this regard. Obviously minimum heat generation within the system is advantageous in that more constant viscosity of the oil will be maintained with more positive assurance of effective lubrication. Reduction in heat developed also precludes abnormal vaporization in certain types of oil and reduces carbon formation.

Various cooling methods have been tried. The use of cooling coils was found to be inefficient, however, and other methods predominate. Several commercial coolers are available for this job. As a rule, these coolers are mounted on the outside of the hydraulic unit or oil reservoir and the discharge from the supercharging pump is sent through the cooler. Usually the discharge oil from the cooler is directed to the end of the reservoir that is farthest away from the pump suction tubes.

Ordinarily, a solenoid-operated water shut-off valve is recommended for the inlet line. The solenoid, being wired to the driving motor, turns the cooler on and off with the motor. A throttle valve to regulate the volume of water is recommended in the outlet line and should be installed in the highest water connection to reduce air pocketing. Throttling the outlet compresses the remaining air and forces it into solution with the water, thus insuring a filled water chamber.

The oil circuit should include a relief valve to protect the pump if the cooler becomes clogged. A T-connection should be provided in the oil inlet line for checking peak or shock pressures. An emergency shut-off valve should be used also in the water line to the cooler.

One method of cooling provides for oil-piping surrounded by cooling fins at the outboard end of the electric motor. A fan attached to the rotor adjacent to these coils passes a current of air over the cooling element.

Of the detrimental results which may accrue from pumping hot oil, reduction in viscosity, or body of the oil, is most important. Along with this reduction in viscosity, the pressure resisting ability of the oil film will be decreased. Considering that at certain stages of the stroke of any such pump there will be severe thrust pressures developed, it is evident that an overheated oil film may become so weakened as to be incapable of actually preventing metal-to-metal contact. Where this occurs between bronze and steel, the latter may develop a wiping effect, the bronze being virtually melted or burned onto the oppos-

ing steel surface. This will necessitate expensive overhaul and new parts.

In connection with oil cooling, careful consideration must be given to the arrangement and tightness of the water cooling system, due to the detrimental effect which water leakage may have on lubrication. This is one of the chief reasons for recommending high grade oils. Presence of any appreciable amount of water may lead to formation of emulsions with certain types of oil. In a closed system, such as an hydraulic power transmission system, where there is normally but little opportunity for the oil to rest and separate itself from water emulsions, oxidation may develop with subsequent sludge formation. All this will be aggravated under the higher temperatures.

Sludge tends to accumulate in clearance spaces, ports or other small apertures in the pump, to interfere with free flow and leakage of the oil past those parts which require a lubricating film. Sludge accumulations in some oils may also be conducive to acidity, which may lead to corrosion of ball or roller bearing elements and other polished parts.

Air Entrainment

Hydraulic power transmission systems function best when they are entirely filled with oil and are as free as possible from air. This excludes the reservoir, of course. For this reason, filling of the system requires considerable care. Air usually gains entry while filling the transmission with oil, unless there may be leakage at some high point in the system, or between the tank and pump. Normally, however, any aperture capable of leaking air will also allow oil to pass out, especially when the pump is operating at full stroke. Entry of air may also be caused by leaky joints, restriction of the pump intake, which may be caused by sludge accumulations, or location of this inlet above the surface of the oil in the tank. The latter may frequently occur if the oil is being rapidly circulated through the system.

Entry of air at the time of filling can be materially reduced by adding make-up-oil very slowly and where practicable straining through several thicknesses of cheese-cloth. After filling with oil, if the pump is run for a certain length of time, any entrained air will gradually work its way out of the oil in circulation and into the base of the pump housing, from whence it will rise to the expansion tank after the pump is shut down. Removal of such air can also be accelerated by locating a baffle plate in the oil tank. This will develop a certain amount of surging and facilitate rise of air bubbles. Lighter oils can be more easily freed from air than heavier oils. It is important to bear this in mind when first running the pump after filling the oil, the time of running being gauged according to the viscosity of the oil. Normally this must be determined by experience.

The expansion tank also serves as a reservoir to insure that there is sufficient oil in the system and serves in determining when to refill.

Considerable care must also be observed to prevent entry of abrasive foreign matter at the time of filling the transmission since contact surfaces in both pump and fluid motors are machined to high accuracy. Presence of abrasives in the oil supply, or acids which may have been used in pickling of piping or connections, may be responsible for scoring or pitting of the pressure surfaces, or may ruin ball or roller bearings.

Hydraulic Hints for Shop

(1) Oil reservoir should be kept closed to all chips and foreign matter.

(2) Strainers should be used when filling reservoirs and should be cleaned regularly.

(3) In changing oil, flush or wash out pumps or system only with good clean oil. Don't use kerosene, gasoline, or similar solvents.

(4) Clean oil filter periodically.

(5) Drain oil frequently if machine is in constant use to check oil cleanliness. If automatically filtered and tested periodically, oil may be used for several years. Some units require complete drain and refill every three months, or oftener.

(6) Use only oils recommended by the manufacturer. Life of unsuitable oils is short, the cost of reclaiming or recharging is higher than necessary, and maintenance may be excessive.

(7) Keep oil at the level indicated or called for in instructions.

(8) Don't use dirty containers to convey oil from the barrel or source of supply to the fluid power reservoir.

(9) Be sure to keep cutting lubricants out of the fluid power system and away from the fluid power pump reservoir.

(10) When repairing hydraulic system and pumps handle them carefully to prevent damage to parts that are made with high accuracy.

(11) Foam on the tank or jerky feeds indicate presence of air in the system. If oil is at level required by sight glass, and suction pipe is far enough below surface of oil, check the filter, all fittings and valves for possible leaks.

(12) Where solenoid valves are used, inspect them for poor connections or badly fitted, loose or corroded contacts in the circuits as these tend to increase current flow, in turn, decreasing their effective pull.

(13) Don't draw packings up too tight as added friction destroys the efficiency and timing of the hydraulic system.

Troubles Traceable to Oil

Machine Trouble	Trouble in Hydraulic System	Fault in Fluid Medium
Sluggish action in normal operation	VALVES & PISTONS SLOW Deposits and gumming hinder free movement	OXIDATION
	OIL SLUGGISH Fluidity has gradually decreased in service	Increased viscosity due to EVAPORATION
		Increased viscosity due to OXIDATION
	OIL SLUGGISH Fluidity not adapted to service	UNSUITABLE VISCOSITY
Sluggish action in starting and in cold weather	OIL SLUGGISH Congealing at low temperature	HIGH POUR TEST
Varying action from hour to hour or day to day	FLUID ACTION VARIABLE Fluidity varies widely with changes in operating temperature	VARYING VISCOSITY
Imperfect, unreliable or irregular action in normal operation	VALVES SEAT POORLY Accumulation of deposits prevents closing	OXIDATION
	VALVES & PISTONS WORN Leakage causes loss of pressure	LOW LUBRICATING VALUE
	COMPRESSIBILITY Foaming of oil carries air into system and provides elastic cushion which prevents positive action	HIGH SURFACE TENSION

CHAIN TENSIONING DEVICES

MAINTENANCE OF PROPER CHAIN TENSION is accomplished by two general methods: shaft center adjustment and adjustable idlers. In many instances the first is sufficient, particularly when shaft centers are close together or not too far from horizontal. Long centers, small sprockets, pulsating or shock loads, or reversing service often make the use of idlers necessary. Use of idlers is also advantageous in enabling wide variation in shaft center tolerances and in increasing the arc of chain wrap.

TYPES OF TENSIONING DEVICES. Idler sprockets or rollers; shoes. Rollers are used when wear is not appreciably increased on roller chain or when applied to the back of chains having teeth on one side. The same applies to shoes. Wear is minimized if they are cast iron or are faced with fibre.

MOUNTING. A rigid mounting is recommended by some chain manufacturers but spring-held idlers are satisfactory in some applications. In automatic tensioners activated by springs the eccentric bushing gives a degree of rigidity beyond that of the spring alone or some kind of detent may be incorporated in the device.

LOCATION. Proper location of an idler depends on the drive design. In general the slack side, where the greatest amount of slack accumulates, is recommended, with the idler bearing preferably on the back of the chain, as close to the driving sprocket as may be feasible or near the smallest sprocket in the drive.

LENGTH OF ADJUSTMENT. Sufficient to enable removal of two pitches.

IDLER SPEED. Idler sprockets must not rotate at greater speeds than are allowable for other sprockets.

IDLER SPROCKET TEETH. At least 17 teeth are preferred in idler sprockets for high-speed service. At least three should mesh with the chain.

CHAIN REPLACEMENT. Should be when chain elongates 3 to 4 percent.

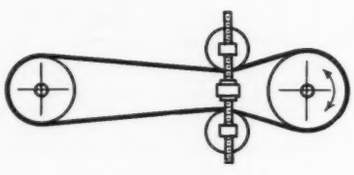


FIG. 1

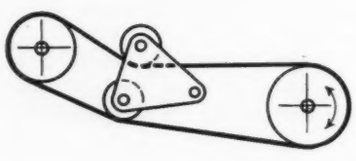


FIG. 2

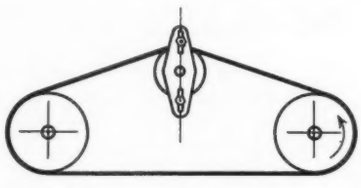


FIG. 3

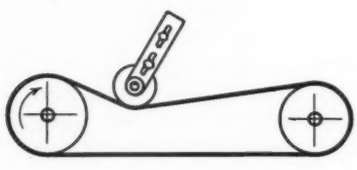


FIG. 4

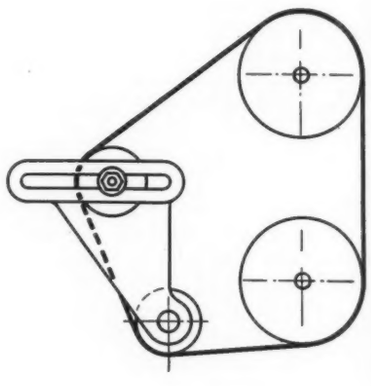


FIG. 5

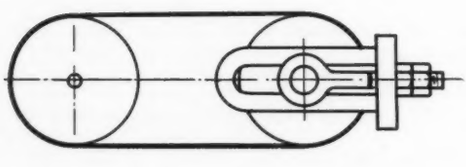


FIG. 6

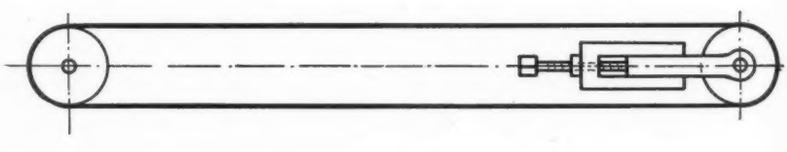


FIG. 7

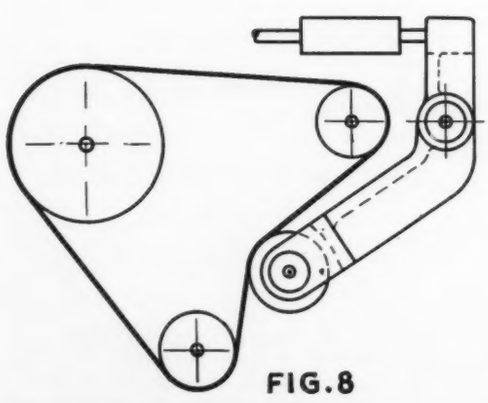


FIG. 8

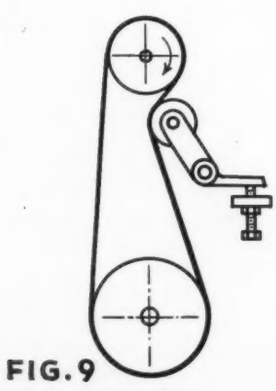


FIG. 9

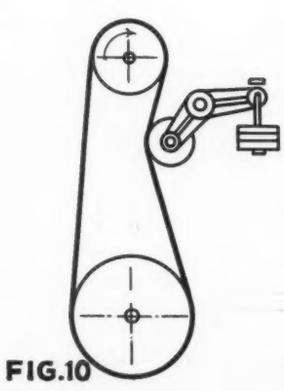


FIG. 10

FIG. 11

Center Adjustments and Idlers

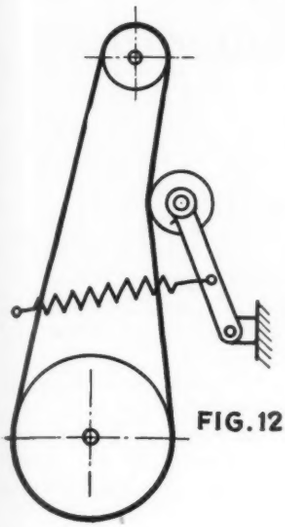


FIG. 12

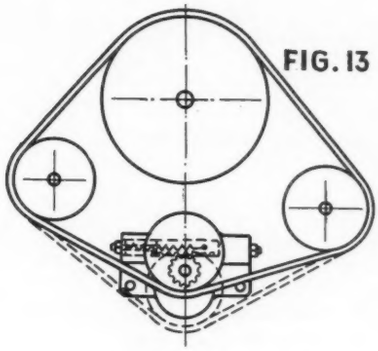


FIG. 13

Automatic adjustment

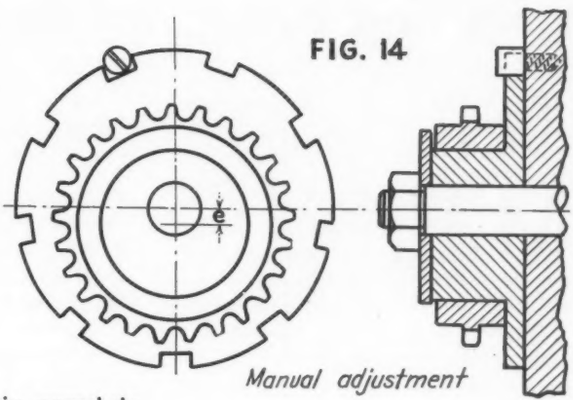


FIG. 14

Manual adjustment

Eccentric sprockets

4 e > 1 pitch

Example = 1 in. pitch e = $\frac{7}{8}$ or $\frac{9}{8}$ in.

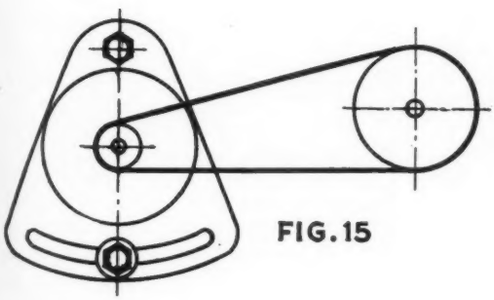


FIG. 15

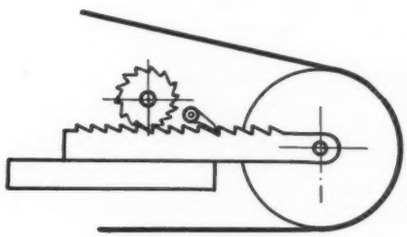


FIG. 16

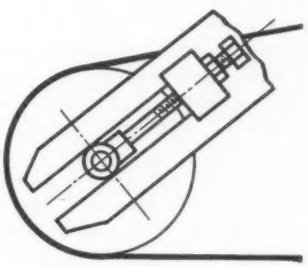


FIG. 17

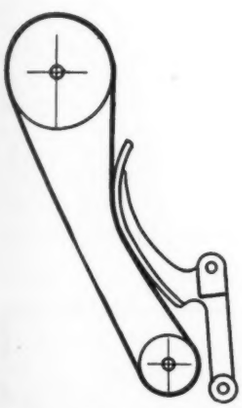


FIG. 18

FIG. 19

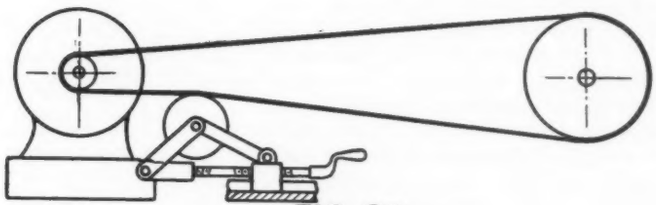


FIG. 20

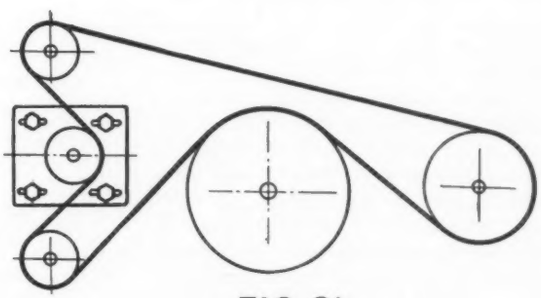


FIG. 21

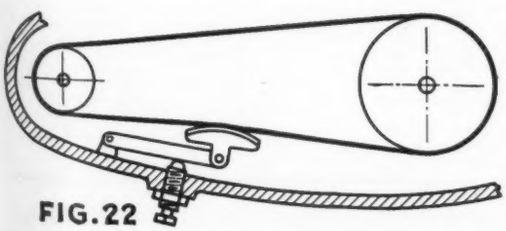


FIG. 22

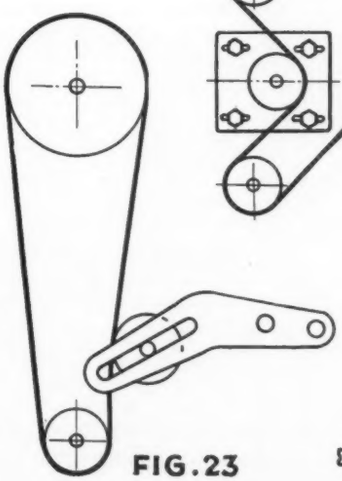


FIG. 23

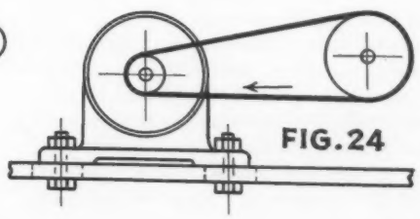


FIG. 24

PIVOT BEARING DESIGN

Friction Error and Bearing Pressure Considerations

J. H. GOSS
Engineer, General Electric Company

MOVING ELEMENTS of indicating electrical instruments are generally supported on bearings consisting of cone-shaped pivots with rounded points which rest in V-shaped jewels having concave bottoms. Experience has shown that this type of bearing maintains the moving element with a minimum of eccentricity with respect to the fixed element. This factor is of prime importance since any eccentricity that is variable will be reflected in variations in the pointer deflection for a given change in the measured quantity. For certain applications special instruments may employ a cupped jewel or ring and end-stone jewels to advantage, but their use is limited.

As an approach to the method of designing pivot bearings for indicating instruments, it will be helpful to start with the general case of an instrument having V-jewels and conically-shaped pivots on both ends of the shaft. This type can be used with its shaft in either the vertical or horizontal plane.

For true indications it is evident that the deflecting torque of the instrument must either equal the restoring torque or differ from it by a constant value that can be taken into account in calibrating the scale. In as much as friction is a variable quantity, it is impossible to obtain a constant difference between the torques, therefore, the maximum bearing friction must be reduced to a relatively low value for satisfactory operation.

Should it be possible to carry the weight of a moving vertical-shaft system on a theoretically sharp point, the friction radius would be zero and there would be no friction error. Low friction, however, is not the only consideration in the determination of the dimensions of a bearing. Service conditions impose shocks and jars of such magnitude on the pivot that greater mechanical strength is required to resist their effects than is required to support the weight of the element. Hence when designing the bearing two major requirements must be balanced against one another in selecting the proper pivot for a given instrument: (1) The pivot point must be sharp enough to limit the friction torque to a reasonable value. (2) The pivot point must also be strong enough to stand up under service conditions.

Recently experiments have been made by V. Stott to determine allowable bearing pressures for pivot bearings (See "An Investigation of Problems Relating to the Use of Pivots and Jewels in Instruments and Meters" by V. Stott, *National Physical Laboratory*, Vol. XXIV, 1931). These experiments consisted of loading pivots up to a limit where permanent deformation occurred and then measuring the area of the flattened pivot point. From the data thus obtained Stott determined that for an included pivot angle greater than 30 deg. the maximum allowable stress was a function of the pivot cone angle and that permanent deformation occurred plastically, and also that the allowable stress increased with an increase in the cone angle.

The radius of the circular bearing area for a properly designed pivot and jewel of the type shown in Fig. 1, can be expressed in terms of

W = weight, lb.
R_p = radius of pivot point, in.
m = Poisson's ratio for pivot material
m_1 = Poisson's ratio for jewel material
E_o = Young's modulus for jewel material
E_1 = Young's modulus for pivot material
R = radius of circular contact area of pivot and jewel, in.
P = average bearing pressure, lb. per sq. in.

$$R^3 = \frac{3\,W\,R_p}{4}\left(\frac{1-m_1^2}{E_o}+\frac{1-m^2}{E_1}\right) \quad (1)$$

The average bearing pressure P is equal to the weight of the instrument moving system divided by the supporting area or

$$P = \frac{W}{\pi\left[\frac{3\,W\,R_p}{4}\left(\frac{1-m^2}{E_1}\right)\right]^{2/3}} \quad (2)$$

This equation was developed on the assumption that the contact area of the pivot and jewel is determined by the elastic constants of the material, and that since the steel pivot is softer than the sapphire jewel ordinarily used, all the deformation takes place in the pivot. It was further assumed that the contact area is circular in shape and that the pivot and jewel may be considered as equivalent to a sphere resting on a flat plate. It can be shown mathematically that the difference in contact area between the sphere and plate and the pivot jewel is small and for the purpose of comparison and design can be neglected.

The series of curves plotted in Fig. 2 were calculated from Equation (2) to illustrate the variation of bearing pressure with the radius of the pivot point for different weights of moving systems carried as shown in Fig. 1. It is difficult to conceive that any material can withstand compressive stresses as high as those shown in Fig. 2. The condition is not, however, simple compression but a combination of tension and compression that results in a working stress well within the limits of the strength of the glass-hard high-carbon steel ordinarily used.

Since the pivot of a vertical shaft like that shown in Fig. 1 is supported by an exceedingly small bearing area the unit pressures are unusually large, therefore, a relatively small shock to the instrument such as setting it down heavily on a table or otherwise mishandling it, may result in mushrooming the point. If the moving element has a solid shaft, a given shock will be more severe to the pivot than if the moving element includes a resilient coil to which the pivots are attached.

An instrument will withstand a much greater shock if it is applied at right angles rather than parallel to the shaft because the weight is divided between

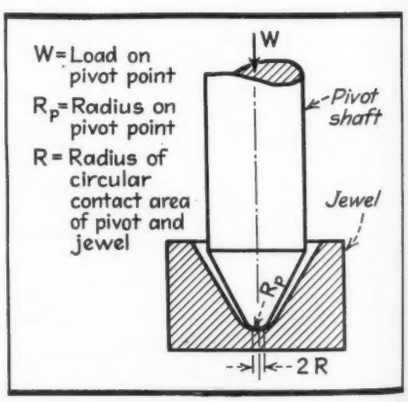


Fig. 1—Typical design of pivot end and section through cupped jewel bearing

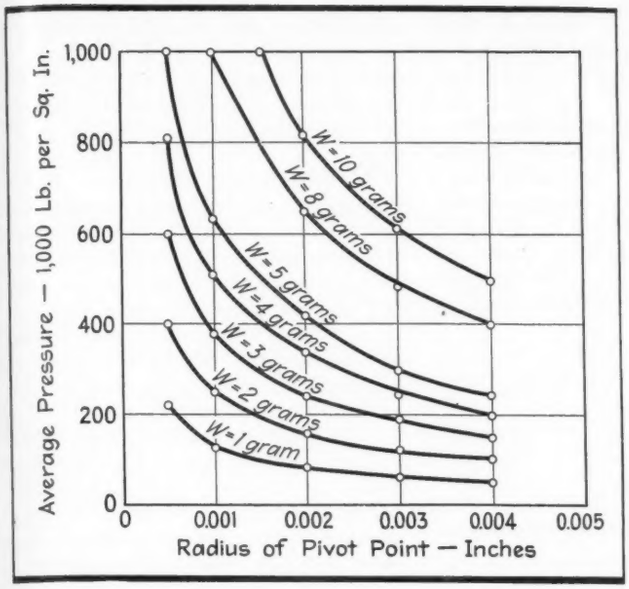


Fig. 2—Average bearing pressure over contact area of pivot point and jewel for various radii of pivot point

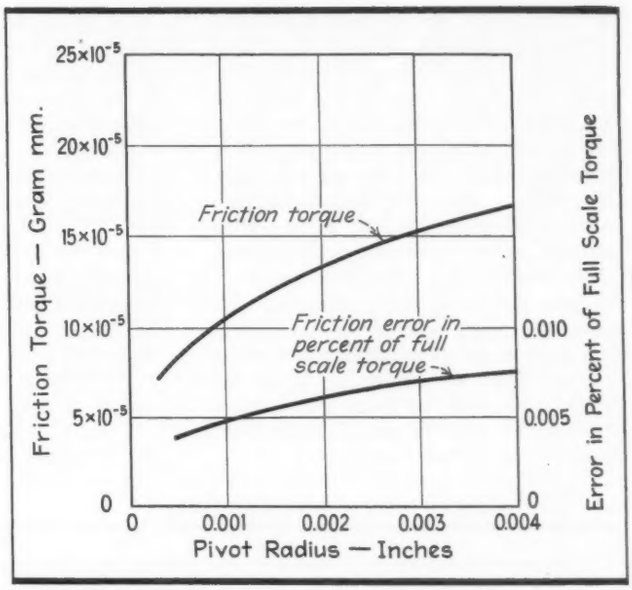


Fig. 3—Variation of friction torque with pivot radius for a vertical shaft instrument

the pivots, and the moving element, even if it is of the solid shaft construction, has considerable flexibility. The condition is equivalent to a beam supported at both ends with the load either distributed or concentrated at the middle.

The friction effect of a mushroomed point resulting from a shock on a vertical pivot may be small if the instrument is used with the shaft vertical, but if the same instrument is used with the shaft horizontal, the effective friction radius will be considerably increased.

In the design of a bearing for a given application it is possible to calculate accurately the friction that will result from a pivot of particular dimensions. The pivot radius should be made as large as the friction will permit, which, as seen from Fig. 2, will give the maximum mechanical strength. The jewel will necessarily have a slightly larger cone angle and bottom radius than the pivot. The amount of eccentricity the particular application can stand will be the limiting factor in the amount of freedom that can be allowed between the pivot and jewel. Aside from the effect of eccentricity, the more general requirements for the jewel are that it have a good polish and that it be free from flaws. The dimensions of the jewel, as will be seen from the calculation of horizontal shaft friction, have little effect upon the magnitude of the friction error.

Considering an instrument to be used with the shaft in either the horizontal or vertical plane, it is important to investigate the effect of the radius of the pivot point on the friction error for the two positions of the shaft.

For a pivot properly designed so that the bearing pressure is not over 500 tons per sq. in. the friction torque for the shaft in the vertical position may be written in terms of

μ = coefficient of sliding friction
R = radius of circular contact area of pivot and jewel, in.
T_f = friction torque, gram mm.

$$T_f = \left(\frac{3\pi\mu}{16}\right) W R \qquad (3)$$

Substituting the value of R from Equation (1) in Equation (3), the friction torque

$$T_f = \frac{3\pi\mu W}{16}\left[0.75\, W\, R_p\left(\frac{1-m^2}{E_1}\right)\right]^{1/3} \qquad (4)$$

Curves of friction torque and of friction error as a function of pivot radius are shown in Fig. 3. The curve of friction torque was calculated from Equation (4) for an instrument with the constants

Torque	2.2 gram-mm. for 90 deg. deflection
Weight of moving element	2.7 grams
Length of Pointer	2.875 in.
Coefficient of friction	0.05

It is interesting to compare the effect of increasing the pivot radius with the resultant change in pivot friction and bearing pressure as shown by Fig. 2. With few exceptions, friction represents such a small percentage of the instrument driving torque that in designs where the vertical position of the shaft alone need be considered, a very sturdy pivot can be used without exceeding the allowable friction error.

Having considered the friction variation with the radius of the pivot for the vertical position of the shaft, an analysis will be made to show how this error varies with the radius for the

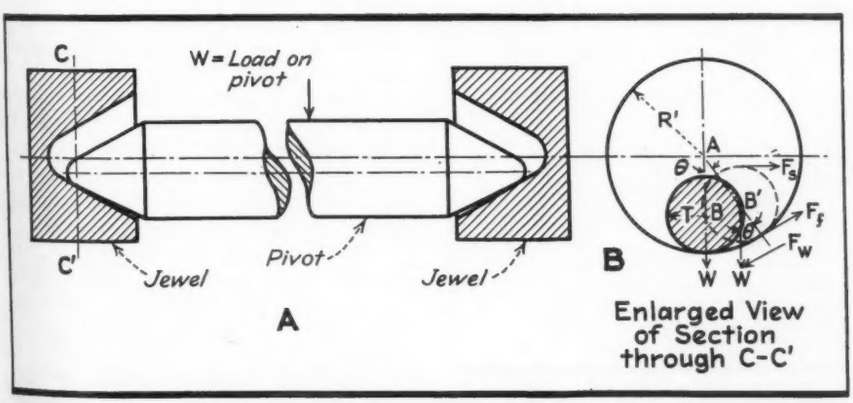


Fig. 4—(A) Pivot shaft mounted in cupped jewel bearings. (B) When pivot turns there is an initial roll of the pivot in the bearing after which a sliding action takes place

shaft when in the horizontal position.

The pivoted shaft shown in Fig. 4(*A*) is supported between two V-jewels. Fig. 4(*B*) shows a cross-section through *C-C'*, the point of contact of the pivot and jewel. As energy is applied to the instrument the pivot because of friction rolls on the jewel from the initial position *B* corresponding to the zero position of the pointer until position *B'* is reached, where the pivot begins to slide on the jewel and continues to do so as the pointer moves up the scale. If the power is removed after the pivot reaches point *B'* the forces will be in equilibrium, and the pointer will indicate a zero position on the scale that is above the initial position.

The curve in Fig. 5 illustrates the variation of friction torque between the rolling and sliding phases of the pivot on the jewel as the pointer moves up scale. The expression for ϕ the angle, in degrees, of roll of the pointer which is determined from the equilibrium condition may be written as an approximation, in which it is assumed for simplicity that for small angles the cosine is approximately equal to 1 and the sine approximately equals the angle in radians. When

K_s = spring force per radian
μ = coefficient of sliding friction

$$\phi = \frac{W r \mu}{K_s} \qquad (5)$$

If the power is removed from the instrument at the point of equilibrium as expressed by Equation (5), the pointer will be off zero by the amount $L\phi$, where L is the length of the pointer and ϕ is the angle the pointer is off zero.

The effect of roll as seen from Fig. 5 is to reduce the friction error up to the point where sliding begins. A larger driving torque would have to be supplied before the pointer would move from zero if it were not for the rolling of the pivot on the jewel. As soon as the sliding begins, however, the friction error is increased and remains a constant value as the pointer moves up scale.

For certain applications where a long pointer is used and small angular movements are involved, the effect of roll becomes important as it allows a small working range either side of the zero point that has relatively low friction. The error introduced by sliding may be expressed in percent of full scale torque by

$$\text{Percentage error} = \frac{\mu W r \cos\theta \times 100}{T} \qquad (6)$$

in which θ is the angle of pivot roll in the jewel before slipping takes place, and T is the instrument torque.

However, as θ is small $\cos\theta$ is approximately equal to 1. The derivation of Equation (6) comes from a consideration of Fig. 4(*B*). The frictional force of sliding is $W'\mu \cos\theta$ and r is the moment arm.

The torque caused by sliding friction for the instrument previously considered for the vertical shaft when used with the shaft horizontal is shown in Fig. 6 as a function of the pivot radius. Comparing the magnitudes of the friction errors resulting from the vertical and horizontal positions of the shaft for the same instrument, it is evident that when the shaft is in the horizontal position the friction errors are greater. Also one curve in Fig. 6 plotted from Equation (5), shows the angle of roll as a function of pivot radius.

As a summary of this analysis three conclusions can be drawn:

(1) It is possible to predetermine the error caused by bearing friction for an instrument to be used with the shaft in either the vertical or the horizontal position, and from a consideration of the bearing pressures involved to predict the relative amount of mechanical abuse the bearings will withstand.

(2) The pivot friction error for a vertical shaft instrument is much less than for the same instrument when used with the shaft in the horizontal position.

(3) Pivot bearings should be designed for the particular application on the basis of using the largest bearing radius the friction error will permit.

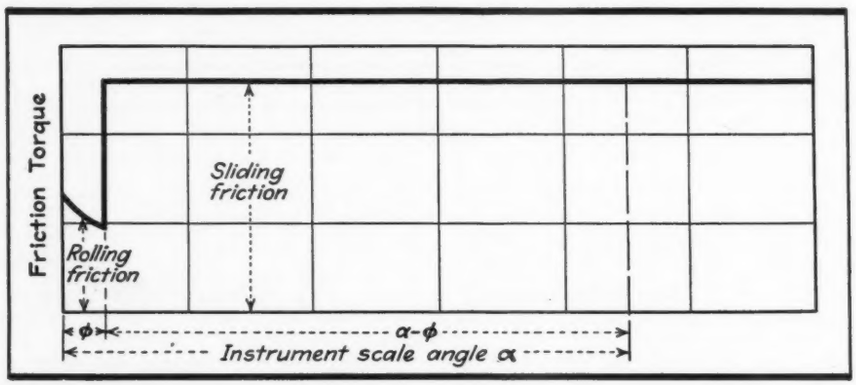


Fig. 5—Curve showing variation of friction torque with angle of pointer deflection as the pointer moves up the scale when pivot shaft is horizontal

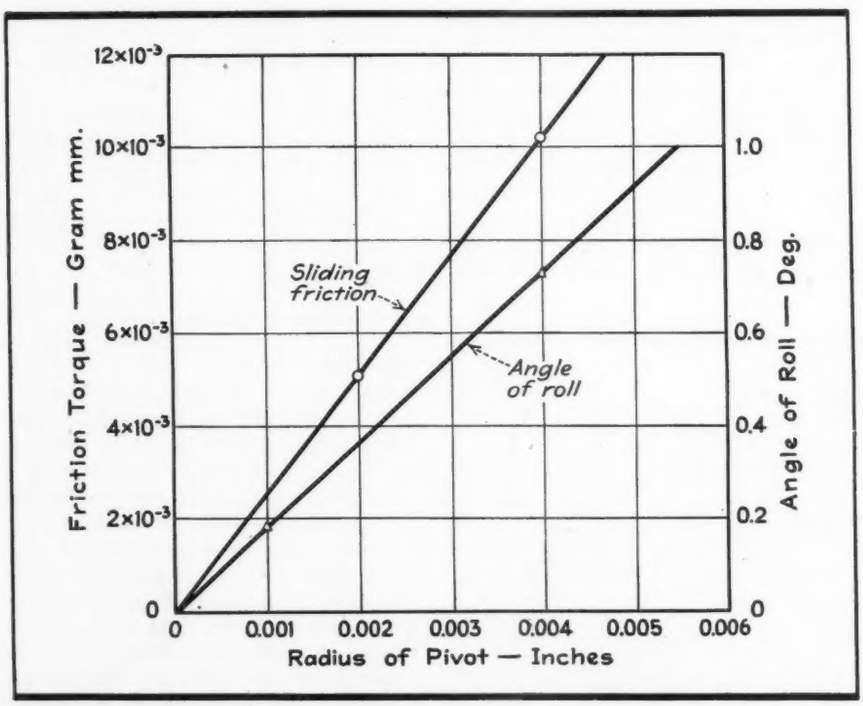


Fig. 6—Torque caused by sliding friction for a horizontal shaft instrument which has the same constants as those for the vertical shaft instrument plotted in Fig. 3. A comparison of the curves shows the difference in friction errors

POLYSTYRENE PROPERTIES

Polystyrene materials are thermoplastic and, therefore, can be molded by either compression or injection processes. Compression molding, however, is recommended only for producing sample pieces from existing molds when available in order to make experimental studies before starting production.

TYPICAL APPLICATIONS FOR POLYSTYRENE PLASTICS

REFRIGERATOR PARTS exposed to food acids, cleansing agents, variations in humidity and low temperatures, such as freezing unit doors, drip traps and food containers.

REFRIGERATOR PARTS used for decorative trim such as panels, knobs, dials and breaker strips.

DECORATIVE PARTS of crystal-clear plastics which have depressed or recessed designs of reversed letters, numerals or patterns molded into the back surface, and the depressions filled with color. Contrast is obtained by painting the back surface with another color.

INDIRECT LIGHTING of instruments and for edge lighting halo effects.

COLORED LIGHT REFLECTORS, indicators, signs and ornamental jewelry where material having a high refractive index is required.

RADIO and television coil forms, stand-off insulators, sockets, high frequency lead-ins and co-axial cable spacers.

CLOSURES FOR CONTAINERS used to store or to hold during transportation mineral acids and alkaline solutions.

INSTRUMENT HOUSINGS, speedometer and clock crystals.

GENERAL CHARACTERISTICS—In compounding the polystyrene group of molding materials it is not necessary to include plasticizers to assist or to improve the capacity of the material to flow under the application of heat and pressure. Therefore, polystyrene parts do not undergo dimensional changes caused by plasticizers vaporizing after the part has been molded. Polystyrene parts after cooling undergo only slight dimensional changes as the part ages.

Another advantage of the absence of plasticizers in polystyrene is that there are no vapors coming from the parts. In the case of materials made with plasticizers, the emanating vapors may cause corrosion of or chemical reaction with parts with which the vapors come in contact. Another factor that promotes the dimensional stability of polystyrene parts is the low capacity of the material to absorb water.

Other properties that distinguish polystyrene molded parts are low specific gravity, transparency, high gloss finish, low power factor, high dielectric strength and insulating capacity, and resistance to alkalies and acids.

(See the article, "Polystyrene Plastic," P.E. August 1941, for additional data, including strength-temperature relationships.)

LIGHT TRANSMISSION AND APPEARANCE PROPERTIES

In translucent and opaque colors polystyrene is only slightly affected by the action of light. Because of its high refractive index and ability to conduct light around bends, as well as to diffuse light at roughened edges, polystyrene is used for many instrument, sign and indicator parts.

The availability of polystyrene in all colors and pastel shades makes it a desirable material for decorative parts and trim. This appearance value and the ability of the material not to become brittle or lose strength at temperatures as low as −30 deg. C. has led to its adoption for trim and interior parts of refrigerators.

Table I—Physical and Electrical Properties of Polystyrene Plastics

(Data furnished by the Bakelite Corporation)

WEIGHT AND VOLUME FACTORS	
Weight of 1 c.c. of powder, grams	0.5
Specific gravity, molded	1.07
Weight of 1 c.c., molded, grams	1.07
Weight per cu. in., molded, grams	17.5
Specific volume, molded, cu. in. per lb.	25.9

PHYSICAL PROPERTIES, Molded	Compression Molded	Injection Molded
Tensile strength—lb. per sq. in. $5\times\frac{1}{2}\times\frac{1}{8}$ in. specimen	5,500–6,500	6,500–7,000
Modulus of elasticity—lb. per sq. in.	$0.4–0.6\times10^6$	$0.375–0.425\times10^6$
Impact strength ft.lb.—energy to break $5\times\frac{1}{2}\times\frac{1}{8}$ in. specimen with molded notch	0.20–0.35	0.4–0.6
Impact strength ft.lb.—inch of notch	0.40–0.70	0.8–1.2
Impact strength ft.lb.—in. sq.	2.5–4.4	5.0–7.5
Flexural strength—lb. per sq. in.	6,500–7,500	14,000–19,000
Shrinkage—inch per inch	0.004–0.005	0.002–0.008

(*Continued on next page*)

PHYSICAL PROPERTIES, Molded (Continued)

Distortion under heat, none up to	77–80 deg. C.
Water absorption (318 hr. 2½ in. dia. disk)	0.05 percent by weight
Index of refraction	1.592–1.597
Rockwell hardness	M85–M92
Thermal coefficient of linear expansion	65–75 $\times 10^{-6}$ per deg. C.
Specific heat	0.32 gm. calories per deg. C.

ELECTRICAL PROPERTIES, Molded

Dielectric strength at 60 cycles, volts per mil. (step by step)	500–525
Volume resistivity, megohm cm	over 10^9
Arc resistance (proposed ASTM Method)	120–140
Power factor at 60 cycles	0.0002–0.0003
Power factor at 1,000 cycles	0.0002–0.0003
Power factor at 1,000,000 cycles	0.0002–0.0003
Power factor at 10,000,000 cycles	0.0002–0.0003
Power factor at 50,000,000 cycles	0.0002–0.0003
Dielectric constant at 60 cycles	2.50–2.60
Dielectric constant at 1,000 cycles	2.50–2.60
Dielectric constant at 1,000,000 cycles	2.50–2.60
Dielectric constant at 10,000,000 cycles	2.50–2.60
Dielectric constant at 50,000,000 cycles	2.50–2.60
Loss factor at 60 cycles	0.0005–0.0008
Loss factor at 1,000 cycles	0.0005–0.0008
Loss factor at 1,000,000 cycles	0.0005–0.0008
Loss factor at 10,000,000 cycles	0.0005–0.0008
Loss factor at 50,000,000 cycles	0.0005–0.0008

RESISTANCE TO ACIDS, ALKALIES, OILS AND HYDROCARBONS

Polystyrene plastic molded parts soften and swell in acetone. They are soluble in coal tar hydrocarbons such as benzol, xylol and toluol; in chlorinated hydrocarbons such as carbon tetrachloride and chloroethylene; in acetic esters of the lower aliphatic alcohols; in the hydrogenated naphthalenes, decalin and tetralin; and in solvent naphtha.

Of all the materials in the organic plastics group, polystyrene ranks first in non-absorption of water; based on 24-hour tests the water absorption is 0.00 to 0.03 percent. Polystyrene is insoluble in petroleum hydrocarbons, in the lower aliphatic alcohols such as ethanol and methanol, in glycol esters and lactic acid esters.

Table II—Chemical Resistance Properties of Injection Molded Polystyrene

(Data obtained from tests made by the Bakelite Corporation)

Chemical Agent	Time	Effect on Samples	Chemical Agent	Time	Effect on Samples
Hydrochloric acid, conc.	14 mo.	Few "stars" developed	Bromine, liquid	.....	Immediate attack
Hydrofluoric acid, conc.	1 mo.	"Stars" developed	Chlorine, gaseous, over 25% conc.	.....	Immediate attack
Nitric acid, conc.	3 wk.	Turned yellow	Iodine tincture, alcohol 83%	33 mo.	Slight pink discoloration
Nitric acid, conc.	2 yr.	Fell to pieces when handled	Diacetone alcohol	.....	Immediate attack
Nitric acid 50% + hydrofluoric acid 0.5%	25 days	No attack	Lanolin	10 mo.	No attack
Sulphuric acid, conc.	33 mo.	Turned slightly yellow	Mercuric chloride	1 wk.	No attack
Sulphuric acid 10% + sodium sulphate 20%	33 mo.	No attack	Methyl chloride	30 min.	Completely dissolved
Acetic acid, 5%	27 mo.	No attack	Milk	2 wk.	No attack
Acetic acid, glacial	14 mo.	Crazed	Phenol 5% + sodium phenate 5%	28 mo.	No attack
Formic acid, 90%	15 mo.	No attack	Phenol 90%	.....	Immediate attack
Tannic acid, 1%, at 170 deg. F.	3 wk.	Dark stain developed	Selenium monochloride	.....	Immediate attack
Alcohol, benzol denatured	24 hr.	Softened and dissolved	Sulphonated alcohol	6 mo.	No attack
Alcohol, ethyl, 95%	2 yr.	Crazed	Thionyl chloride	6 hr.	Dissolved
Butanol	27 mo.	No attack	Benzoin tincture, alcohol 80%	2 wk.	No attack
Octyl alcohol	21 mo.	No attack	Titanium tetrachloride	.....	Immediate attack
Ammonium hydroxide, conc.	14 mo.	Few "stars" developed	Vinegar 25%	17 mo.	No attack
Sodium hydroxide, 40%	9 mo.	No attack	Hydrogen peroxide 3%	13 mo.	No attack
Sodium hydroxide, 30%	21 mo.	No attack	Hydrogen peroxide 3%	22 mo.	Few "stars" developed
Potassium hydroxide, 30%	15 mo.	No attack	Gasoline, room temperature	.....	Softened immediately
Ethylene diamine, 25%	22 mo.	Turned slightly yellow	Motor oils, room temperature	1 yr.	No attack
Triethylene tetramine	22 mo.	Turned slightly yellow	Petroleum jelly	15 mo.	No attack
Glycerine	17 mo.	No attack	Castor oil	2 wk.	No attack
Oil of anise	.....	Immediate attack	Coconut oil	23 mo.	No attack
Oil of clove	.....	Immediate attack	Corn oil	17 mo.	No attack
Oil of peppermint	.....	Immediate attack	Cotton seed oil	17 mo.	No attack
Oil of pine	.....	Immediate attack	Olive oil	23 mo.	No attack
Orange juice	1 wk.	No attack	Carbonated water at 0.3 deg.C.	5 wk.	No attack
Orange peel	1 hr.	Softened and crazed	Water at 65 deg. C.	2 wk.	No attack
Pineapple juice	3 wk.	No attack	Water at 75–80 deg. C.	17 days	Surface whitened and became rough
Pineapple juice	10 mo.	Slightly crazed			

MEEHANITE CASTINGS

The processes used in the production of Meehanite iron castings involve an accurate control of the disposition of the microconstituents and also of both the quantity and form of the graphite, rather than an adjustment of the chemical analysis. A number of specific classifications can be made.

PROCESS AND METALLURGICAL STRUCTURE

In the foundry materials are selected on the basis of qualitative analysis. Melting characteristics also are observed closely. Also, the molten iron is pretested for structural composition and the degree of graphitization is adjusted before pouring the metal into the mold.

In the making of Meehanite, graphitization results from a catalytic process that disperses particles of graphite in the molten iron before solidification. Each particle acts as a nucleus for the formation of a grain so that not only is the formation of columnar crystals reduced, but the whole mass is a fine and dense crystal grain structure that is substantially free from planes of internal weakness, shrink cracks, and columnar crystal embrittlement. Even metal in the sharp angles of castings is claimed to be of an equiaxed form of crystal structure.

Like gray cast iron and steel, the properties of Meehanite are also affected by the cooling rate and the mass influence. The slower the solidification rate, the coarser is the grain structure with consequent decrease in tensile strength.

Effect of Section Size on Tensile Strength

Section thickness	Tensile strength, lb. per sq. in. Meehanite Type	
in in.	GB	GA
1.2	45,700	52,340
2.	44,000	51,760
3.	42,360	49,800
4.	43,000	48,450
6.	43,800	47,300

In addition to several engineering types, there has been developed five different types of Mehanite which have different combinations of physical properties for parts which are subject to wear of various kinds caused by rubbing friction, corrosion, thermal shock, abrasion, or erosion. Heat resisting types have also been developed that are resistant to growth, warpage, scaling and corrosion. Most of the types of Meehanite resist the penetration of steam and gases and do not show any growth or deterioration at temperatures up to 600 deg. F. At higher temperatures, however, the general engineering types of Meehanite are not recommended.

HEAT-TREATMENTS TO IMPROVE PROPERTIES

Stress relieving of Meehanite is carried out at temperatures ranging from 850 to 1,150 deg. F., depending upon the type of Meehanite and the size of the casting.

Machinability is improved, when required, by annealing in which operation care must be taken to prevent excessive graphitization and loss of strength.

The high strength Meehanites are comparable to carbon steel in their response to hardening by quenching in oil from above the critical change temperature. Reheating the casting after hardening or quenching from above the critical temperature directly into a molten lead or salt bath at 500 to 730 deg. F. improves impact properties.

Castings can be hardened on the surface or locally by flame hardening. Points to remember when designing

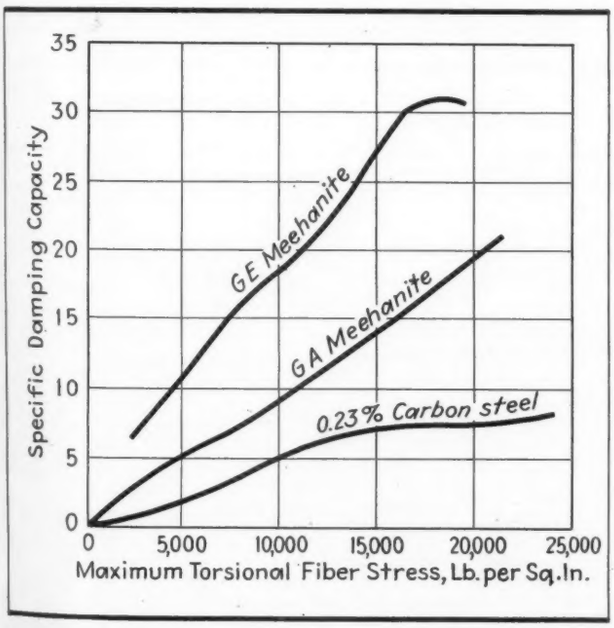


Fig. 1—Specific damping capacity of GE and GA types of Meehanite

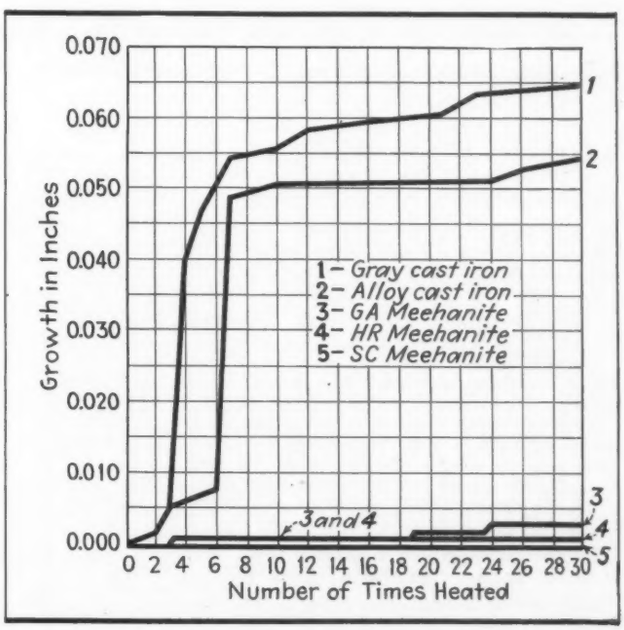


Fig. 2—Relative growth of various materials after heating to 1,600 deg. F. a number of times

Table I—Physical Properties of Meehanite Castings

Properties	General Engineering Types					
	GM	GA	GB	GC	GD	GE
Tensile strength — 1,000 lb. per sq. in.	55	50	45	40	35	30
Modulus of elasticity — 10^6 lb. per sq. in.	23.0	21.0	19.0	17.5	15.0	12.0
Transverse strength of 1.2 in. bar — 18 in. centers						
Load — lb.	3,300–3,700	3,100–3,600	3,000–3,400	2,900–3,300	2,600–3,000	2,000–2,600
Deflection — in.	0.28–0.34	0.28–0.34	0.28–0.34	0.26–0.34	0.22–0.34	0.20–0.34
Modulus of rupture — 1,000 lb. per sq. in.	93.0	88.95	84.7	82.0	74.1	61.0
Compressive strength — 1,000 lb. per sq. in.	200.0	175.0	160.0	150.0	130.0	120.0
Fatigue strength — 1,000 lb. per sq. in.	25.0	22.0	19.0	17.5	15.0	13.7
Impact strength — Charpy — ft.-lb.	8.0	7.2	5.8	4.5	3.2	2.1
Torsional strength — 0.75 in. dia. x 14.5 in. long						
Fibre stress ultimate — 1,000 lb. per sq. in.	64.0	60.0	55.9	45.9	40.1	35.3
Degrees twist	99.3	98.7	76.1	64.3	56.7	49.2
Shear strength — 1,000 lb. per sq. in.	Over 55.0	48.0	44.0	40.0	35.0	30.0
Damping capacity — 20,000 lb. per sq. in.						
Torsional stress energy dissipated 1st cycle, percent	21.0	24.0	25.0	28.0	30.0	32.0
Brinell — as cast	>217	>207	>196	>192	>183	>174
Thermal conductivity — 50–450 deg. F. B.t.u./hr./sq.ft./in. thickness/deg. F.	355	350	345	325	300	290
Coefficient of thermal expansion per deg. F. — from 100–1,000 deg. F. 10^{-6}	6.91	6.87	6.84	6.77	6.70	6.66
Magnetic permeability — Kilolines — per sq. in.						
40 ampere turns per in.	49.0	48.0	44.2	42.6	42.5	38.1
100 ampere turns per in.	60.1	63.5	61.3	59.5	59.3	54.8
Coercive force amp. turns per in. at 64.5 kilolines per sq. in.	44.6	43.5	41.2	32.9	27.5	22.2
Machinability rating — Dalcher	50	48	48	47	44	38
Specific gravity	7.48	7.43	7.37	7.25	7.13	7.02
Freezing range — deg. F.						
Incipient	2,330	2,325	2,300	2,252	2,230	2,210
Main	2,120	2,120	2,100	2,107	2,100	2,100
Phosphide	.....	.....	1,760	1,751	1,750	1,750
Electric resistance microhms per cu. cm.	42	50	.....	.....	.....	78
Specific heat — 0 to 212 deg. F.	.....	0.13	.....	.....	.....	.....
At 1,800 deg. F.	.....	0.175	.....	.....	.....	.....
Latent heat of solidification — Gram calories	0.72	0.8	1.2	2.0	3.1	5.4
Carbide change A. R.— deg. F.	1,365	1,370	1,375	1,380	1,385	1,395
Solid contraction — in. per ft.						
Patternmaker's shrinkage	5/32	5/32	1/8–5/32	1/8	1/8	1/10–1/8

Properties	Heat-Resisting Types				Corrosion-Resisting Types
	HD	HC	SC	HR	CC-CB
Maximum working temperature — deg. F.	1,150	1,400	1,650	1,550	.....
Tensile strength — 1,000 lb. per sq. in.	33	38	27	40	42
Modulus of elasticity — 10^6 lb. per sq. in.	17.5	19.5	17.5	21.0	19.0
Transverse strength of 1.2 in. bar — 18 in. centers					
Load — lb.	2,600	2,860	1,500	2,860	3,000
Deflection — in.	0.24	0.26	0.17	0.24	0.30
Modulus of rupture — 1,000 lb. per sq. in.	67.0	76.0	37.0	76.0	77.0
Compressive strength — 1,000 lb. per sq. in.	145.0	160.0	130.0	162.0	160.0
Fatigue strength — 1,000 lb. per sq. in.	16.0	19.0	20.0	19.0	19.0
Shear strength — 1,000 lb. per sq. in.	34.0	40.0	28.0	42.5	42.0
Damping capacity — 20,000 lb. per sq. in. torsional stress energy dissipated 1st cycle, percent	27.0	23.0	.....	19.0	26.0
Brinell — as cast	>202	>229	>300	>229	>187
Thermal conductivity — 50–450 deg. F. B.t.u./hr./sq.ft./in. thickness/deg. F.	325	360	278	360	325
Coefficient of thermal expansion — per deg. F.— from 100–1,000 deg. F. 10^{-6}	7.09	7.28	6.74	7.43	6.81
Solid contraction — in. per ft.					
Patternmaker's shrinkage	1/8	5/32	5/32	5/32	5/32

castings that are to be flame hardened:

1. Extra stock is desirable on light castings to take care of warpage and cleanup.

2. Holes should be avoided, but when necessary they should be countersunk. There should be a minimum of ¼ in. between the edge of the casting and the outside of the holes.

3. Avoid designs which involve sudden changes from heavy to light sections. Use fillets generously.

4. Wall sections and ribs adjoining a hardened surface should not be less than ½ in. thick.

Table II—Properties Under Heat Influence

Temperature Deg. F.	Approx. tensile strength lb. per sq. in.			Maximum growth In. per in. per year		
	HD	HC	HR	HD	HC	HR
800	3,800	.....	.....	Nil	.....	.....
900	3,800	.....	.....	Nil	.....	.....
1,000	3,200	6,000	.....	Nil	Nil	.....
1,100	2,300	3,750	4,000	0.002	Nil	.....
1,150	1,600	3,000	3,150	0.005	Nil	.....
1,200	.....	2,250	2,500	.....	0.001	0.001
1,300	.....	1,600	1,800	.....	0.002	0.002
1,400	.....	800	900	.....	0.005	0.005
1,450	.....	.....	300	.....	.....	0.010

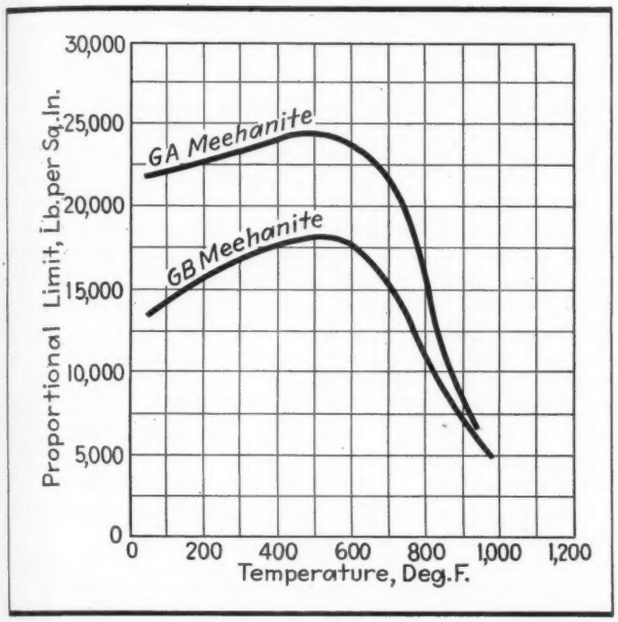


Fig. 3—Effect of temperature on the proportional limit of types GA and GB Meehanite

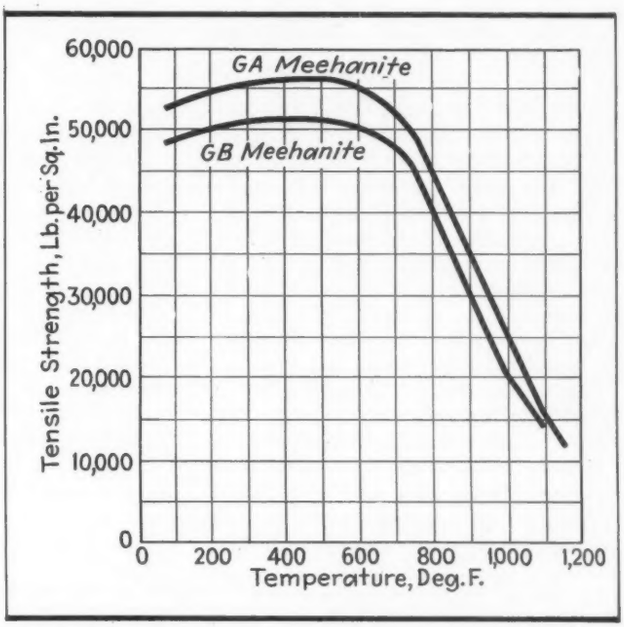


Fig. 4—Effect of temperature on the tensile strength of types GA and GB Meehanite

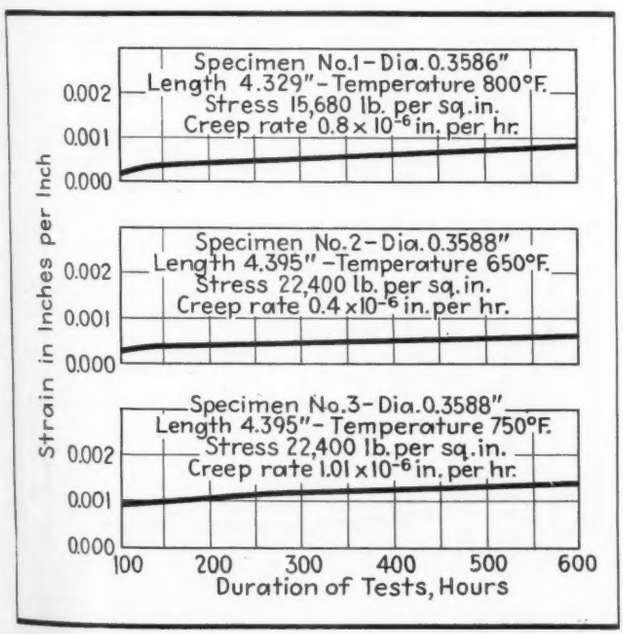

Specimen No. 1 - Dia. 0.3586"
Length 4.329" - Temperature 800°F.
Stress 15,680 lb. per sq. in.
Creep rate 0.8 x 10⁻⁶ in. per hr.
Specimen No. 2 - Dia. 0.3588"
Length 4.395" - Temperature 650°F.
Stress 22,400 lb. per sq. in.
Creep rate 0.4 x 10⁻⁶ in. per hr.
Specimen No. 3 - Dia. 0.3588"
Length 4.395" - Temperature 750°F.
Stress 22,400 lb. per sq. in.
Creep rate 1.01 x 10⁻⁶ in. per hr.
Strain in Inches per Inch
0.002
0.001
0.000
100
200
300
400
500
600
Duration of Tests, Hours

Fig. 5—Creep tests of type GA Meehanite at various temperatures and time up to 600 hours

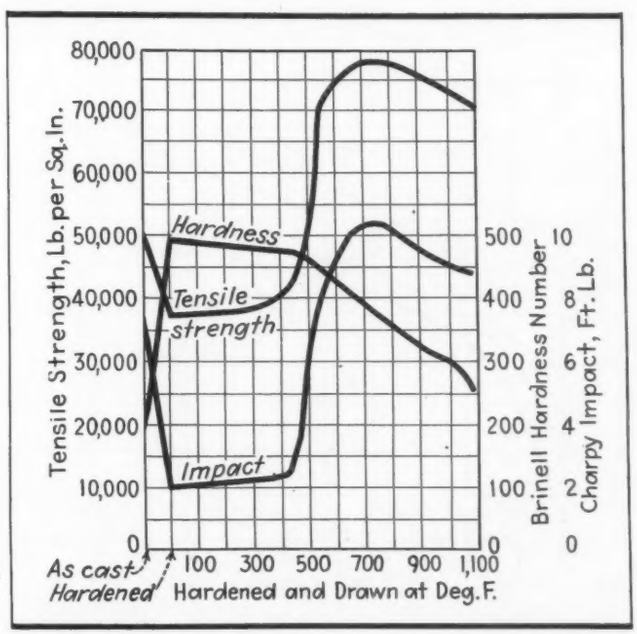


Fig. 6—Effect of heat-treatment on physical properties of type GA Meehanite

PROPERTIES of 85–15 BRASS

R. A. WILKINS and E. S. BUNN
Revere Copper and Brass Incorporated

THE 85-15 BRASS is composed of 85 percent copper and the remainder zinc. This alloy is also known commercially as Red Brass or Rich Low Brass and is available in wire, rod, bars, shapes, sheet, strip, plate, tube and pipe. Among the more important specifications which consider 85-15 brass are A.S.T.M. B134 on wire, A.S.T.M. B36 and U.S. Army 57-160 on sheet and strip, A.S.T.M. B43, B111, and B135, Federal Specification WW-P-541, WW-P-448, WW-P-351, and WW-T-791, U.S. Army 57-190, U.S. Navy 44-P-12c, 44-T-15b, 44-T-16a, A.S.M.E. S24, S27, S47, and SAE74 on pipe and tubing.

This brass has excellent cold working properties and can be spun, drawn, stamped, cold forged and upset. Its hot working properties are similar to copper and, as in the case of copper, lead must be held to a trace in order to avoid cracking during hot working.

In resisting the action of certain chemical reagents, particularly salt, brackish or corrosive inland waters, 85-15 brass offers more resistance than copper. As a consequence 85-15 brass pipe and tubing are used extensively in plumbing and heat exchangers. Unlike brasses of higher zinc content, it is relatively immune to "season cracking" and "dezincification."

In the cold working as well as in the annealing series of charts for strip, it will be observed that properties are given for two different ready-to-finish grain sizes, as in similar brass data in PRODUCT ENGINEERING, October and November. The two values of ready-to-finish grain size, 0.015 mm. and 0.070 mm., were chosen because they represent the limits encountered in the commercial annealing of 85-15 strip.

In order to render 85-15 rod sufficiently malleable for cold drawing, it is common practice to anneal prior to cold working so as to produce a grain size of 0.045 mm. to 0.050 mm.

It will be observed that the mechanical properties are markedly influenced by the ready-to-finish grain size. This is especially true for the cold worked strip series as shown in Figs. 1-4. The amount of cold work is measured in B. & S. numbers hard.

A different range of properties is of course established for each number of hardness as shown in Figs. 1-4. This range is typical of commercial production and as such is recognized in commercial specifications. Control of the ready-to-finish grain size from one lot to another for a given amount of cold work is absolutely necessary in order to secure identical properties in strip brass or 85-15. It will be noted in Fig. 1 that material having a ready-to-finish grain size of 0.015 mm. and cold worked 5 numbers has the same tensile strength as material with a ready-to-finish grain size of 0.070 mm. cold worked 7 numbers hard.

The influence of ready-to-finish grain size on material which has been cold worked 6 numbers (50% reduction) and then annealed, as in Figs. 5-10, is less marked but nevertheless as important. Material having a ready-to-finish grain size of 0.070 mm. has consistently lower mechanical properties at the given annealing temperature than material having a ready-to-finish grain size of 0.015 mm.

Traces of lead and iron are present in this brass. The exact copper contents are 85.42 percent in the strip (Figs. 1-10), 85.68 percent in the rod (Figs. 11-17), and 85.01 percent in the tubing, Fig. 18.

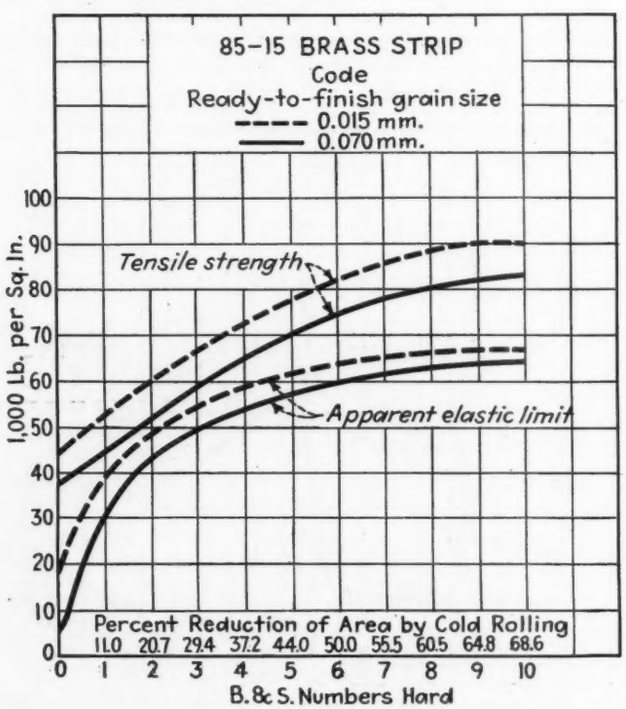


Fig. 1—Effect of cold working on tensile strength and apparent elastic limit of 85–15 brass strip (85.42 percent copper, lead and iron trace, zinc balance) having two different ready-to-finish grain sizes

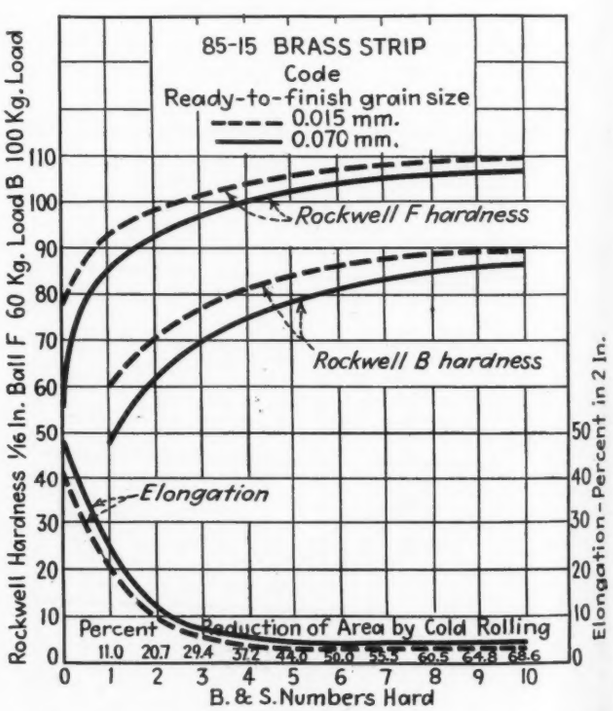

85–15 BRASS STRIP
Code
Ready-to-finish grain size
0.015 mm.
0.070 mm.
Rockwell F hardness
Rockwell B hardness
Elongation
Rockwell Hardness 1/16 In. Ball F 60 Kg. Load B 100 Kg. Load
Elongation - Percent in 2 In.
Percent Reduction of Area by Cold Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B. & S. Numbers Hard

Fig. 2—Effect of cold working on Rockwell F and B hardness and percentage elongation of 85–15 brass strip (85.42 percent copper, lead and iron trace) having two different ready-to-finish grain sizes

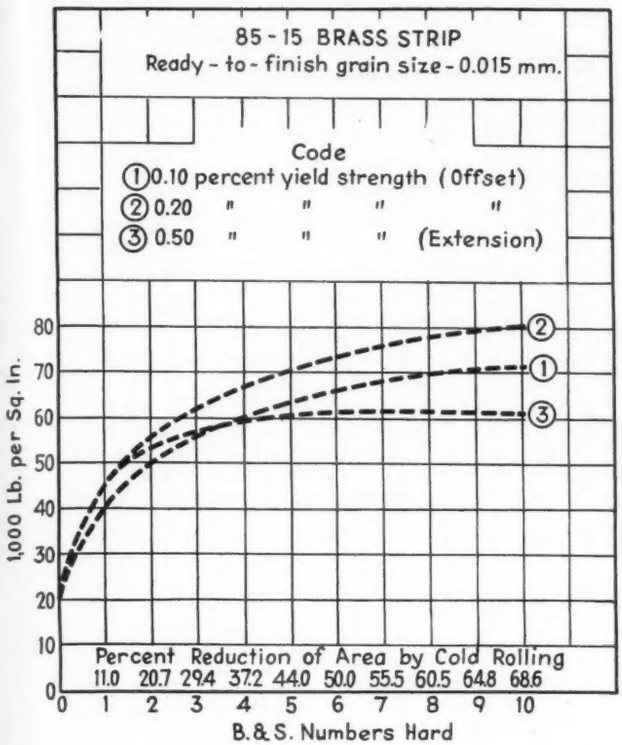

85-15 BRASS STRIP
Ready-to-finish grain size-0.015 mm.
Code
① 0.10 percent yield strength (Offset)
② 0.20 " " " "
③ 0.50 " " " (Extension)
1,000 Lb. per Sq. In.
Percent Reduction of Area by Cold Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B. & S. Numbers Hard

Fig. 3—Effect of cold working on yield strength of 85–15 brass strip as determined by three different methods. The effect of ready-to-finish grain size on yield strength may be compared in Figs. 3 and 4

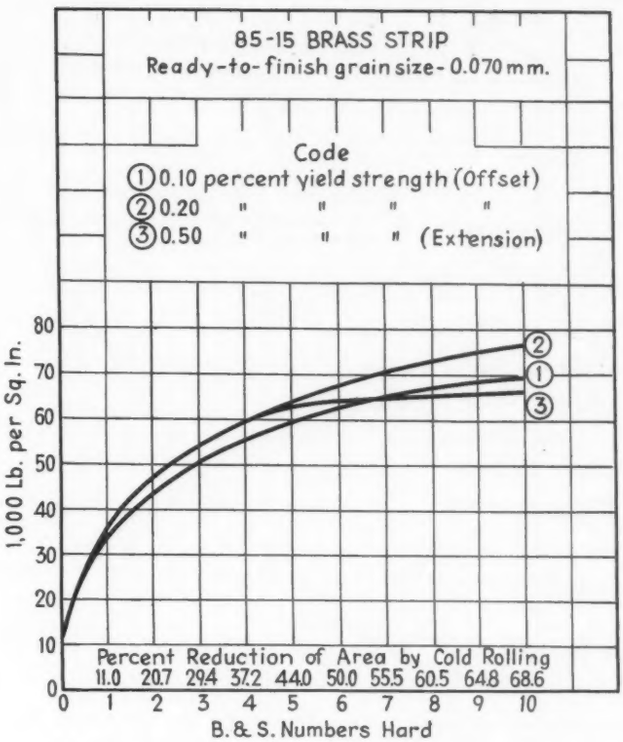

85-15 BRASS STRIP
Ready-to-finish grain size-0.070 mm.
Code
① 0.10 percent yield strength (Offset)
② 0.20 " " " "
③ 0.50 " " " (Extension)
1,000 Lb. per Sq. In.
Percent Reduction of Area by Cold Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B. & S. Numbers Hard

Fig. 4—Effect of cold working on yield strength of 85–15 brass strip as determined by three different methods. The effect of ready-to-finish grain size on yield strength may be compared in Figs. 3 and 4

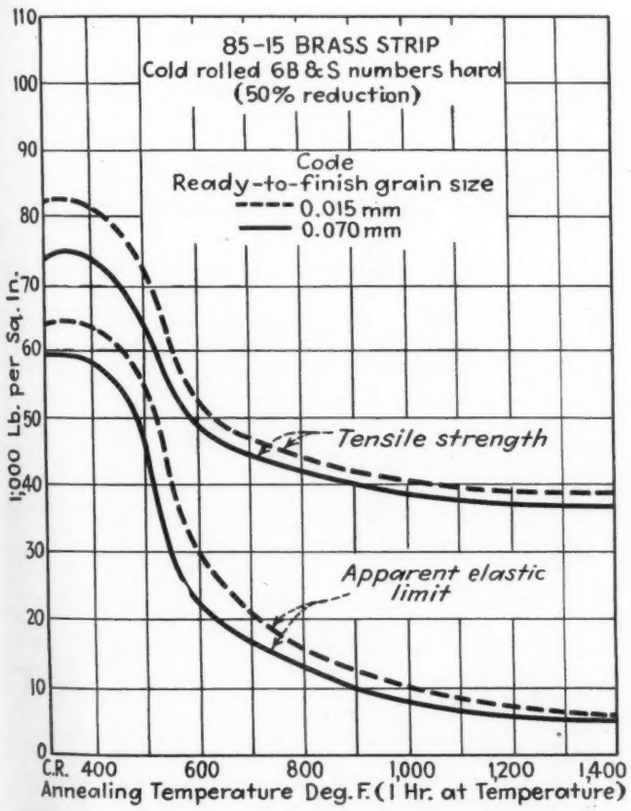


Fig. 5—Tensile strength and apparent elastic limit of 85–15 brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

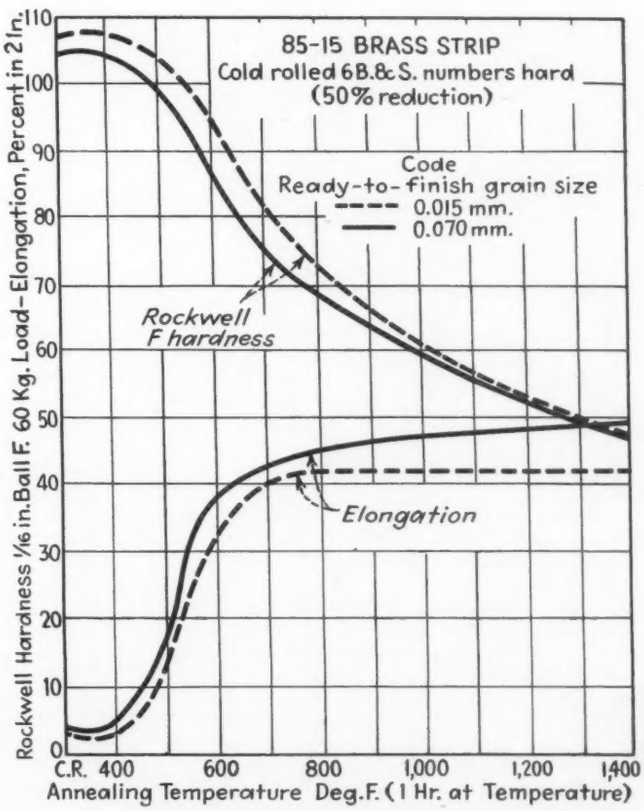

85-15 BRASS STRIP
Cold rolled 6B.&S. numbers hard
(50% reduction)
Code
Ready-to-finish grain size
0.015 mm.
0.070 mm.
Rockwell Hardness 1/16 in. Ball F. 60 Kg. Load - Elongation, Percent in 2 In.
Rockwell F hardness
Elongation
C.R. 400 600 800 1,000 1,200 1,400
Annealing Temperature Deg. F. (1 Hr. at Temperature)

Fig. 6—Rockwell F hardness and percentage elongation of 85–15 brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

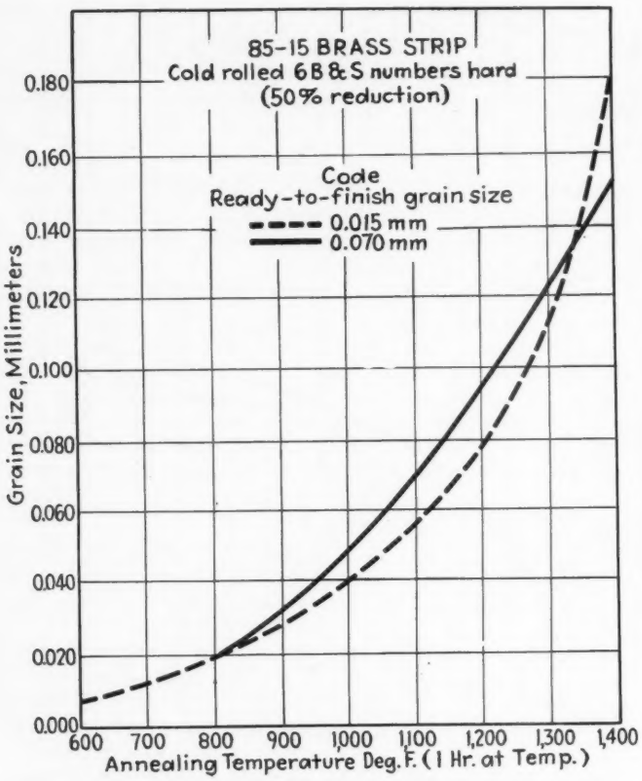


Fig. 7—Grain growth of 85–15 brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

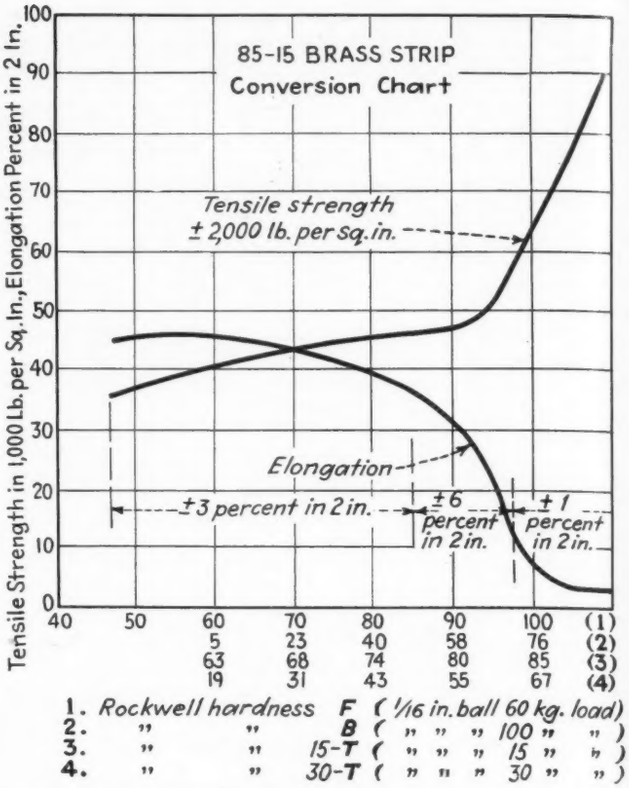

85-15 BRASS STRIP
Conversion Chart
Tensile Strength in 1,000 Lb. per Sq. In., Elongation Percent in 2 In.
100
90
80
70
60
50
40
30
20
10
0
Tensile strength
± 2,000 lb. per sq. in.
Elongation
±3 percent in 2 in.
±6 percent in 2 in.
±1 percent in 2 in.
40 50 60 70 80 90 100 (1)
5 23 40 58 76 (2)
63 68 74 80 85 (3)
19 31 43 55 67 (4)
1. Rockwell hardness F (1/16 in. ball 60 kg. load)
2. " " B (" " " 100 " ")
3. " " 15-T (" " " 15 " ")
4. " " 30-T (" " " 30 " ")

Fig. 8—Approximate tensile strength and percentage elongation of 85–15 brass strip can be determined when only Rockwell hardness is known. Accuracy is within the given limits for all thicknesses between 0.020 and 0.080 in.

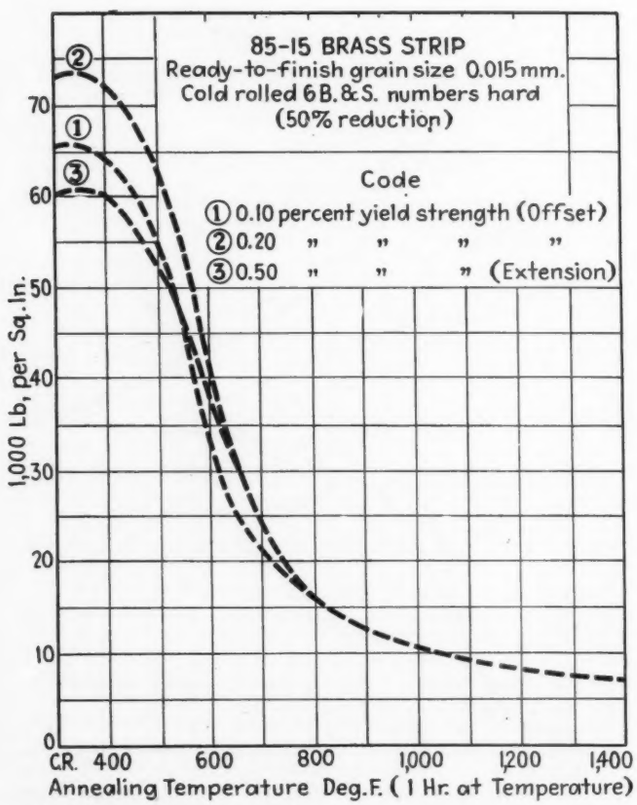


Fig. 9—Yield strength of 85–15 brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

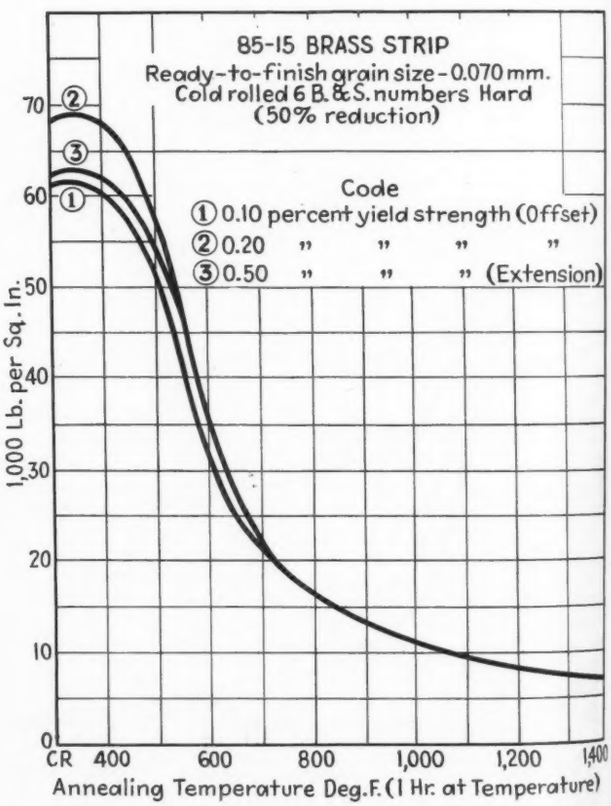


Fig. 10—Yield strength of 85–15 brass strip as affected by ready-to-finish grain size and by annealing after cold rolling to 6 B. & S. numbers hard

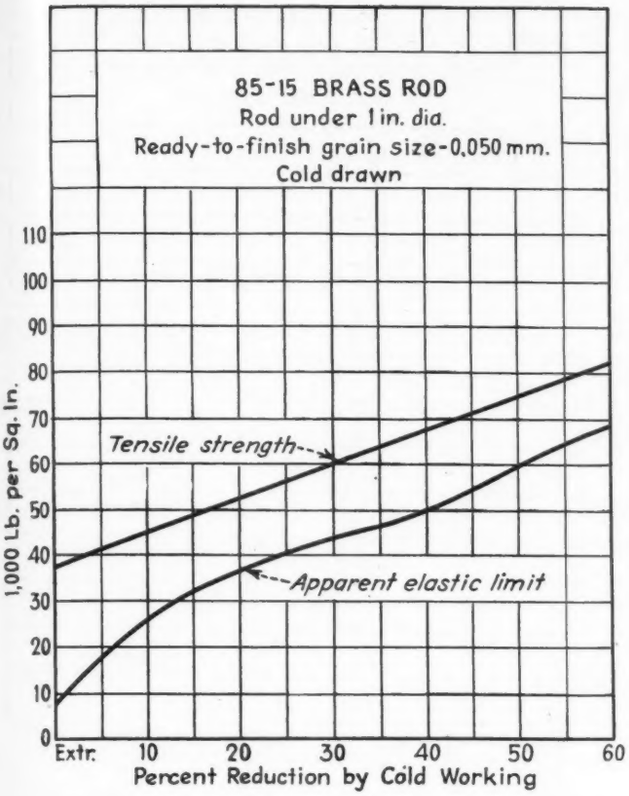

85-15 BRASS ROD
Rod under 1 in. dia.
Ready-to-finish grain size-0.050 mm.
Cold drawn
Tensile strength
Apparent elastic limit
1,000 Lb. per Sq. In.
Extr. 10 20 30 40 50 60
Percent Reduction by Cold Working

Fig. 11—Effect of cold working on tensile strength and apparent elastic limit of 85–15 brass rod having a ready-to-finish grain size of 0.050 mm.

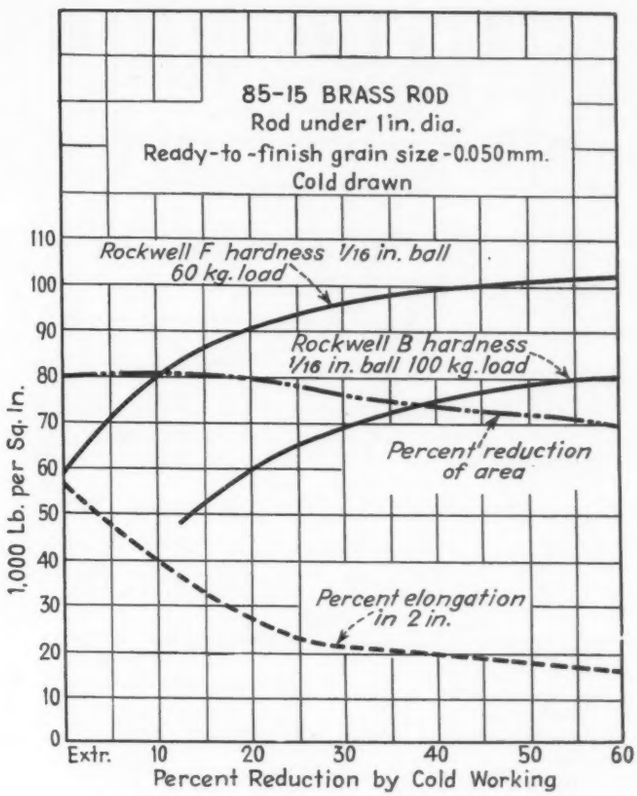

85-15 BRASS ROD
Rod under 1 in. dia.
Ready-to-finish grain size-0.050 mm.
Cold drawn
Rockwell F hardness 1/16 in. ball 60 kg. load
Rockwell B hardness 1/16 in. ball 100 kg. load
Percent reduction of area
Percent elongation in 2 in.
1,000 Lb. per Sq. In.
Extr. 10 20 30 40 50 60
Percent Reduction by Cold Working

Fig. 12– Effect of cold working on Rockwell F and B hardness, reduction of area, and percentage elongation of 85–15 brass rod

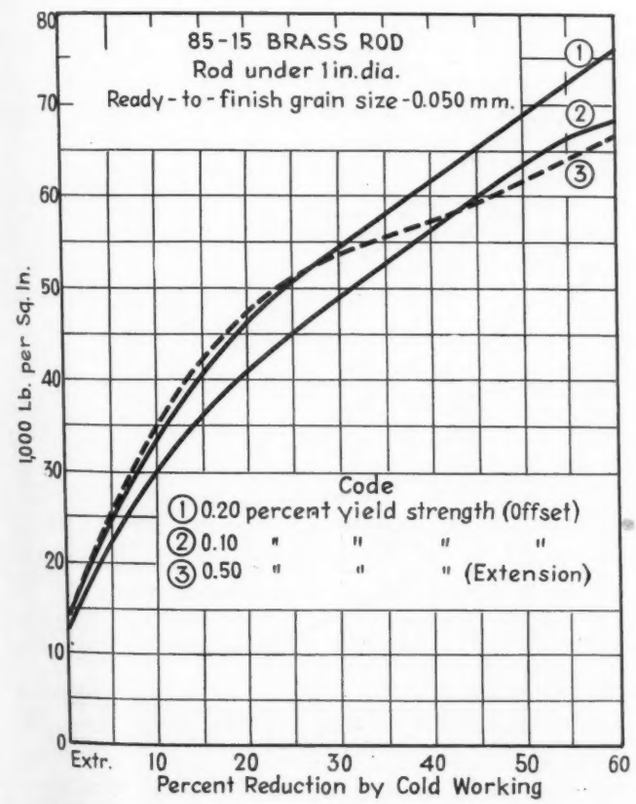

85-15 BRASS ROD
Rod under 1 in. dia.
Ready-to-finish grain size-0.050 mm.
Code
① 0.20 percent yield strength (Offset)
② 0.10 " " " "
③ 0.50 " " " (Extension)
1,000 Lb. per Sq. In.
Extr. 10 20 30 40 50 60
Percent Reduction by Cold Working

Fig. 13—Effect of cold working on yield strength of 85–15 brass rod is shown by three methods

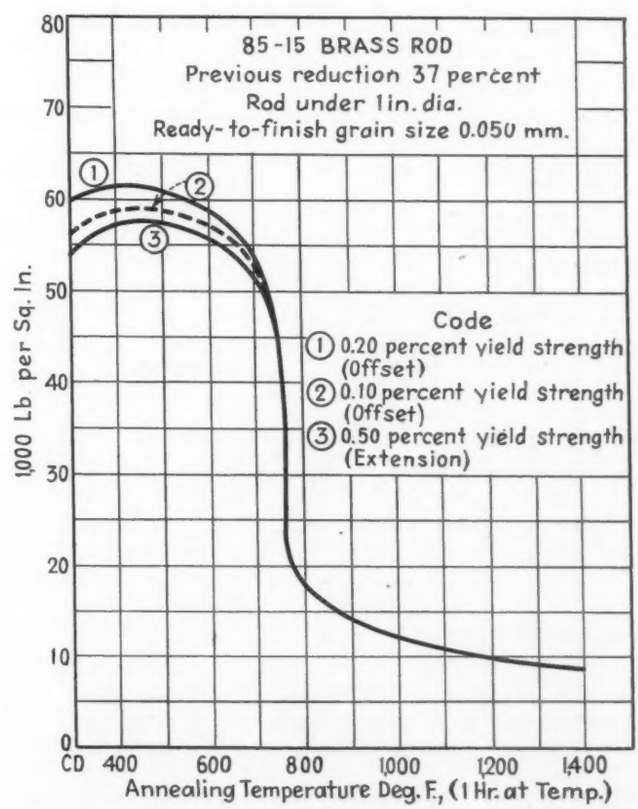

85-15 BRASS ROD
Previous reduction 37 percent
Rod under 1 in. dia.
Ready-to-finish grain size 0.050 mm.
Code
① 0.20 percent yield strength (Offset)
② 0.10 percent yield strength (Offset)
③ 0.50 percent yield strength (Extension)
1,000 Lb per Sq. In.
CD 400 600 800 1,000 1,200 1,400
Annealing Temperature Deg. F., (1 Hr. at Temp.)

Fig. 14—Effect of annealing on yield strength of 85–15 brass rod is shown by three methods

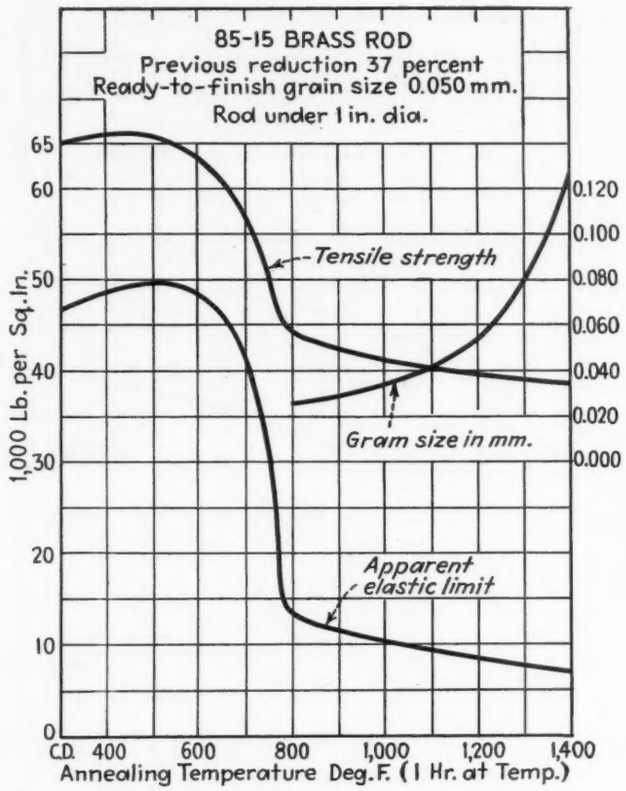


Fig. 15—Effect of annealing on tensile strength, apparent elastic limit, and grain growth of 85–15 brass rod

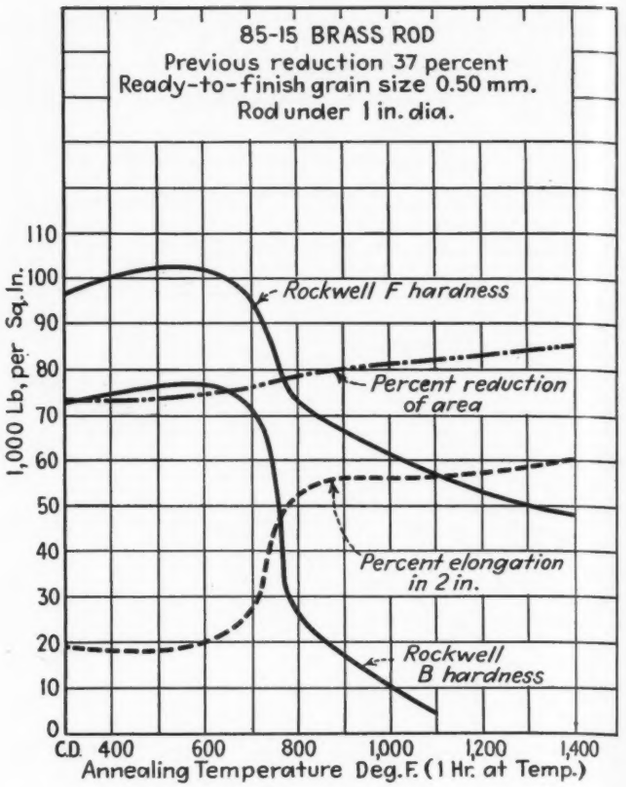

85-15 BRASS ROD
Previous reduction 37 percent
Ready-to-finish grain size 0.50 mm.
Rod under 1 in. dia.
Rockwell F hardness
Percent reduction of area
Percent elongation in 2 in.
Rockwell B hardness
1,000 Lb. per Sq. In.
C.D. 400 600 800 1,000 1,200 1,400
Annealing Temperature Deg. F. (1 Hr. at Temp.)

Fig. 16—Effect of annealing on Rockwell F and B hardness, percentage reduction of area, and percentage elongation

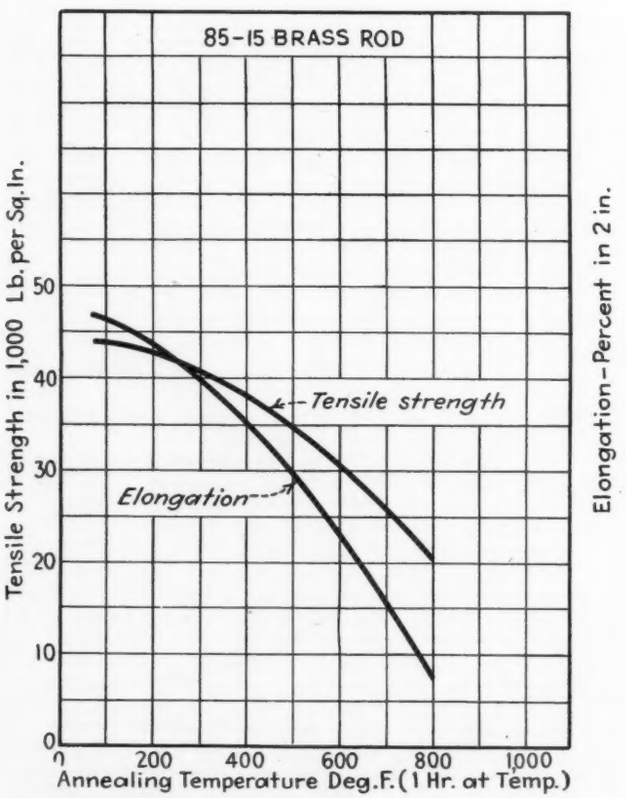

85-15 BRASS ROD
Tensile strength
Elongation
Tensile Strength in 1,000 Lb. per Sq. In.
Elongation - Percent in 2 in.
0 200 400 600 800 1000
Annealing Temperature Deg. F. (1 Hr. at Temp.)

Fig. 17—Effects of elevated temperature on tensile strength and elongation of 85–15 brass rod. Material was held at the temperature one hour prior to testing

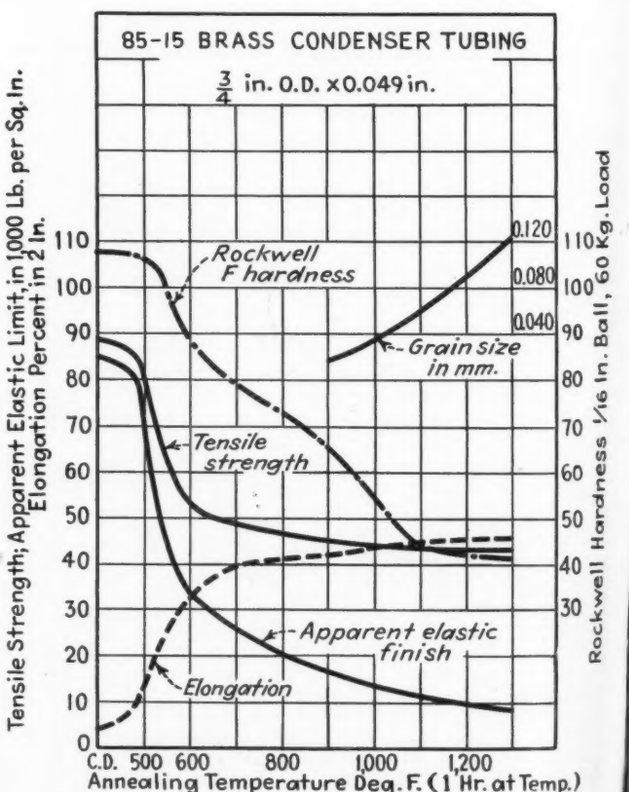

85-15 BRASS CONDENSER TUBING
3/4 in. O.D. x 0.049 in.
Rockwell F hardness
Grain size in mm.
Tensile strength
Apparent elastic finish
Elongation
Tensile Strength; Apparent Elastic Limit, in 1,000 Lb. per Sq. In.
Elongation Percent in 2 In.
Rockwell Hardness 1/16 In. Ball, 60 Kg. Load
0.120
0.080
0.040
C.D. 500 600 800 1,000 1,200
Annealing Temperature Deg. F. (1 Hr. at Temp.)

Fig. 18—Effect of annealing on physical properties of condenser tubing previously given a 65 percent reduction of area by cold working from a ready-to-finish grain size of 0.050 mm.

VULCANIZED FIBRE WITH WOOD CORE

In order to obtain all the advantages of plywood plus other desired properties, special types of ply materials have been developed. One of these, known as Fybr-Tech, manufactured by Technical Ply-Woods of Chicago, consists of a wood veneer core with vulcanized fibre sheets bonded to one or both faces.

GENERAL CHARACTERISTICS— Fibre faces are tough, non-splintering, corrosion resistant, uniform in strength and thickness, and have a smooth surface that requires no preparation for paint lacquer or varnish finishing.

WEIGHT—Weight varies with thickness of fibre facing and total thickness. For a rough approximation, Fybr-Tech has about one-half the weight of aluminum. For estimating weights of sheets of other thicknesses, $\frac{3}{8}$ in. veneer weighs about 1 lb. per sq. ft. and fibre sheet weighs about 0.068 lb. per sq. ft. per 0.010 in. thickness. Weight of the resin bonding or glue can be disregarded.

Weight of Fybr-Tech Sheets

Thickness of Fibre Facings	0.015 in.	0.010 in.	0.007 in.	0.005 in.
Total Thickness in inches	Total Weight in lb. per sq. ft.			
3/32	0.312	0.267	0.241	0.224
1/8	0.387	0.342	0.316	0.299
3/16 (5 ply)	0.537	0.492	0.466	0.499

THICKNESS OF SHEETS—Standard 3 or more ply sheets, consisting of a veneer core and two fibre faces or a veneer core, a fibre face and a veneer back, are obtainable in any total thickness from $\frac{1}{32}$ in. up. Popular thicknesses are $\frac{1}{32}$ in., $\frac{3}{64}$ in., $\frac{1}{16}$ in., $\frac{3}{32}$ in., $\frac{1}{8}$ in. and $\frac{3}{16}$ in. Thickness of the fibre sheet may be 0.015 in., or 0.005 in. The panels can also be made with two veneer faces or with a fibre face and a veneer back. All thicknesses $\frac{1}{8}$ in. and greater are 5 ply with two fibre faces and a 3-ply veneer core.

TENSILE STRENGTH
Three plys, 3/32 in. total thickness

Across Grain	5,500 to 6,000 lb. per sq. in.
With Grain	11,360 to 13,980 lb. per sq. in.

The fibre itself has a tensile strength of 19,000 lb. per sq. in. with the grain and about 8,700 lb. per sq. in. across the grain. The strength of the Fybr-Tech panel will vary appreciably according to the thickness of fibre.

Strength parallel to grain per unit weight is comparable to that of pure aluminum.

WORKABILITY—Can readily be punched, drilled, sawed and machined with ordinary tools. Can be bent to a single curvature on hot rolls to a radius as small as $\frac{1}{2}$ in. Can be shaped more readily than conventional plywood, with virtually equal pliancy both with and across the grain. Can be molded to compound curvatures of large radii.

DIELECTRIC STRENGTH—Dielectric strength varies according to various factors but a minimum of 300 volts per mil thickness can be depended on.

CORROSION RESISTANCE—Resistant to acetic and carbolic acid, ammonia, gasoline, turpentine, linseed oil, cottonseed oil, machine oil and alcohol. Will be injured by strong acids such as nitric, hydrochloric and sulphuric.

FIRE RESISTANCE—The material is slow-burning and does not support combustion. It can be made "fireproof" by a surface treatment.

SURFACE—Tough, scratch-proof, and non-splitting surface. The surface absorbs paints readily, giving a smooth level finish.

WEAR RESISTANCE—Fybr-Tech has all the wear-resisting characteristics of vulcanized fibre.

APPLICATIONS—Is being used successfully to replace aluminum sheets in street cars, buses and passenger trains for interior paneling, headlinings, floors, racks, seat backs and paneling under windows; in trucks and trailers for headlinings, flush paneling, instrument panels, seat backs; in marine construction for cabin paneling, bunks, furniture, ceilings and floors. Has found some applications in aircraft where extreme rigidity is not required.

WHITE BRONZE PLATING

SPECULUM WHITE BRONZE, as electroplated by a recently developed process, gives a hard, durable coating which keeps its warm brilliance and remains untarnished in ordinary atmospheres for an indefinite time. Because of its pleasing color, brightness, hardness, and durability, speculum plating has been suggested as an alternate for stainless metals, for nickel, chromium, and silver plating, and for other corrosion-resistant plated finishes where good appearance is desirable.

The coating is an alloy of tin and copper made by simultaneously plating both metals over any suitable base metal. Between 35 percent and 55 percent of tin can be deposited, however, the standard proportions are tin 40 percent, copper 60 percent. The process has been developed for basic metals such as copper, brass, bronze, nickel silver and tin or lead-base alloys such as pewter.

The process requires equipment and control similar to that of alkaline stannate tin plating. Only one plating bath is used. Since the deposit is only 40 to 45 percent tin, the materials cost is lower than for tin plating.

Surface preparation of the base material consists of obtaining a smooth clean surface as for any other electroplated product. The coating may be plated directly on copper, brass, bronze, nickel silver, and tin or lead base alloys. With steel, an undercoating of nickel or red bronze (10 to 12 percent tin) is recommended. No intermediate cleaning and polishing is necessary for plated undercoat.

Thickness of the speculum electroplated coating naturally depends upon the conditions to which the part is subjected. Thus 0.0005 in. may be adequate for most indoor uses, and 0.001 in. may be desired where more corrosive conditions or greater wear is encountered. The coating is compact and non-porous.

If deposited on a smooth surface, the speculum coating has a satiny finish which may be satisfactory without polishing. Full luster is achieved with light polishing operation.

PROPERTIES OF SPECULUM

COLOR of white bronze is very similar to that of polished silver, is less blue than chromium, and less yellow than nickel. Its relative position on the color scale is shown in Fig. 1. Although almost indistinguishable from silver, it is reported to have a suggestion of warmth. Hitherto white metal decorative schemes have commonly been associated with blue, but the new coating shows to advantage against cream, brown, and other warmer tones.

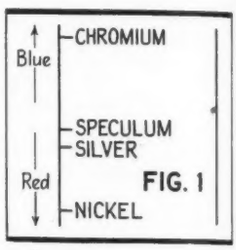


FIG. 1

HARDNESS. Speculum white bronze has a hardness intermediate between that of nickel and chromium. Because of this hardness, it is not easily scratched in normal use.

RESISTANCE TO CORROSION. The coating is quite resistant to alkaline solutions and moderately resistant to acids. In particular, it is unaffected by fruit juices such as lemon and tomato and by liquids such as milk, vinegar and beer. The coatings are not tarnished by traces of sulphur and consequently are suitable for bright metal work in city atmospheres. Speculum plating has not yet been thoroughly tested for outdoor applications, but automobile bumpers plated with the white bronze have withstood corrosion and retained their luster during four months of winter use.

Reflecting Powers of Metals

	White light directly reflected	Color* Silver = 0	
Silver	90%	0	
Chromium	61%	blue-green	12 units
Nickel	50%	red	16 units
Stainless steel	49%	blue-green	3 units
White Bronze Speculum	70%	red	1 unit

*Data in this column were obtained by measuring the excess of red and of blue-green light reflected by various metals and expressing this by an index number with silver as zero.

REFLECTIVITY. Although the reflectivity is less than that of freshly polished silver, it is greater than that of chromium, nickel, or stainless steel. Table above gives a direct comparison of the reflecting powers of freshly polished metal surfaces.

RETENTION OF LUSTER. When subjected to ordinary indoor atmospheric corrosion, the coatings appear to retain their luster indefinitely. After a few week's exposure the comparison with silver, as shown in Fig. 2, is striking.

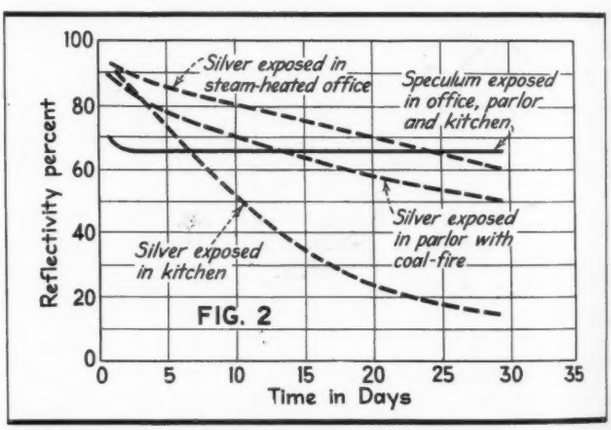


FIG. 2

APPLICATIONS

PRINCIPAL APPLICATIONS of speculum white bronze plating, as developed thus far, are mainly for indoor use. Tests made in outdoor applications indicate that it will be satisfactory wherever a smooth, bright, hard electroplated finish is desired. The speculum electroplating process has been in commercial operation in a Birmingham (England) factory since 1939, which has established that the operation of the process is a satisfactory industrial proposition. American rights are held by City Auto Stamping Company of Toledo.

Question and Comment

Engineering the Patent

JOHN F. CAVANAGH
Boston Wire Stitcher Company

A mechanical engineer is a person capable of expertly supervising any project within the scope of his particular branch of the profession, from its conception through the various stages of design, development, tooling and manufacturing to the usable state without violating any of the tenets of engineering practice. If these considerations were more generally applied to the various stages in preparation and pursuit of patent applications our patent office would not be cluttered with the debris of impractical and worthless patents, and legitimate developments would be more effectively protected.

A general knowledge of patent practice is of course a prerequisite of a good engineer. Hence, we shall not dwell upon such attendant considerations as "at date of conception," "reduction to practice" and "due diligence," indispensably important though they are. In this connection the highly informative current articles of Col. H. A. Toulmin, Jr., in PRODUCT ENGINEERING treat them from the proper standpoint, basic patent law.

Before looking into the matter of claim phrasing let us consider the other two portions of a patent, namely the drawings and specifications. In the general run of factory patents, by that is meant those peculiar to the product of a concern, the patent draftsman may be relied upon to amply illustrate the new mechanism from drawings supplied for the purpose. In cases where patents are to be sold or become the basis of financial exploitation, the engineer should suggest views which will most effectively interest prospective purchasers who in many instances are not technically minded. At least one view should approach a trade catalog illustration. If the application affects a tool or implement, the improvement should be shown in use.

Illustrate all modifications of the invention which come within the claims. If the office uncovers references which read upon the preferred form of the invention, it is usually worth while to narrow the claims to cover another of the illustrated forms. Even if a reference is found which dominates the application, one of the alternative forms may be patented and prove saleable to the party holding the dominating patent. Then again the original patent may have but a comparatively short period to run in which case the later patent on an improvement would have potential value. This procedure could not be followed unless the drawings depicted such alternative forms of the invention.

The foregoing considerations relating to the patent drawings also apply in a lesser degree to the specifications. These should be studied carefully to the end that they describe fully every patentable detail of the illustrations, together with their functions.

A case in point involved a patent on a small piece of electrical mechanism wherein a lever was cam-actuated under certain conditions and electromagnetically actuated under others. In the specifications it was brought out that the electromagnet "might" under certain conditions be utilized to merely "assist" the cam to actuate the lever. While the functions of the device as described did not depend upon such a contingency as the electromagnet "assisting" the cam, nevertheless reference to the fact that the combination could so function proved a deterrent to a later applicant wherein the functioning of an entirely different piece of mechanism actually was entirely dependent upon an electromagnet assisting a cam to operate a lever.

Another such case involved a steam trap wherein a by-pass was shown partly in section and in continuation by dotted lines. While this by-pass was not considered of importance when the case was prepared for filing, due to research during the period of patent office examination the passage became immensely important and further claims were presented covering it specifically. These claims were rejected by the office on the grounds that the specifications did not explicitly state that the dotted lines represented a continuation of the by-pass and the filing of a new application became necessary.

The worth of any patent insofar as a particular invention is concerned resides in the claims. The fruits of painstaking research are sometimes lost because care is not exercised to employ words and phrases which adequately insure protection and the most effective way to build up this protection is to attack the proposed claims as a competitor and lay before the attorney every conceivable modification which may retain the substance of the invention and still dispense with a clause in a claim, bearing in mind that the elimination of but one clause is enough to void a claim.

Some years ago a fully prepared application was laid before an engineer for his casual examination. It concerned an electrical mechanism adjustably mounted in a symmetrical housing. In order to make the mechanism readily replaceable it was controlled by a lever pivoted on the outside of the housing, inter-engagement being effected through a small opening in the side of the housing. The device appeared to be new and of considerable potential value. Hence, the drawings and specifications were carefully prepared and the numerous claims at first sight seemed adequate. In practically every claim, however, appeared the clauses "externally pivoted lever" or "externally mounted means" for effecting adjustment of the mechanism within the housing. The engineer pointed out how easily a competitor could avoid the claims by modifying the housing so as to include the lever pivot. The word "independently" was accordingly substituted for "externally" and eventually a strong patent was issued.

The inventor who is not thoroughly versed in patent practice as affecting the preparation of patent applications would do well by obtaining the advice of a competent engineer. For the manufacturing concern whose products are the subjects of frequent patent applications, intelligent engineering attention to all applications along the foregoing lines is necessary to insure due coverage and to reduce the danger of inter-

ference or litigation to a minimum. Such attention may not be hit and miss in character nor may it be delegated to unqualified assistants.

Mess Kits of Plastic

To the Editor:

On page 564 of your October issue, a letter to the editor suggests that Army mess kits be made of plastics instead of aluminum.

Problem number 1 today would be to secure the plastics. They're about as tight as aluminum.

Problem number 2 would be a suitable plastic, though I believe that is solved through the Durez resin Kys-Ite material made by Keyes Fibre Company, which would have the strength and durability. Keyes' problem is to secure enough material and, as the development is new, production facilities are far too limited to care for Army requirements. —HERBERT S. SPENCER

Durez Plastics & Chemicals, Inc.

Watermelon Rind Complicates Problem

To the Editor:

Mr. Smith's problem of cutting a watermelon into n disk-shaped pieces of equal volume (*P.E. Nov. 1941, p. 621*) was a good one, but it can be made into an extremely interesting mathematical problem if you consider the rind to be waste material.

Then, assuming the melon to be a prolate spheroid (elipse revolved on its major axis) with major axis a and minor axis b, and further assuming that $b = \frac{1}{2}a$, the skin thickness w can be called equal to $b/10$. Then the problem is to divide the edible pulp into n equal parts. —RANDOLPH N. CURRY

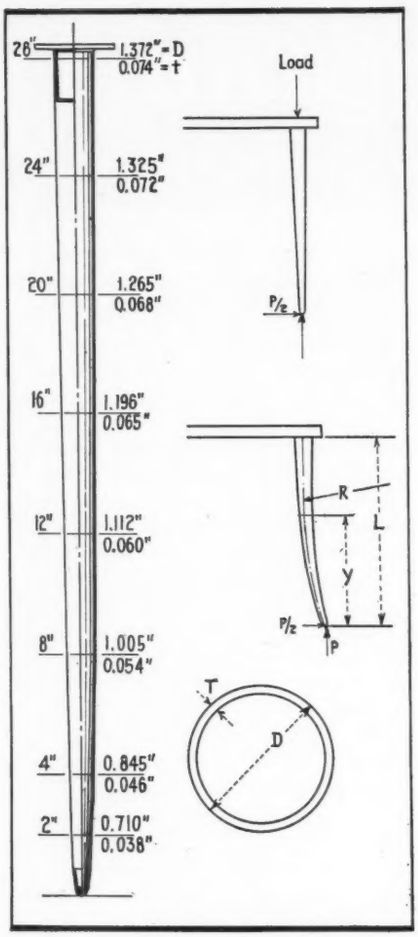
Stamford, Conn.

Table Leg Designed For Uniform Stiffness

To the Editor:

The more perfectly an object is designed for its function, the more beautiful it will be. This maxim can be applied to the table leg described herein which is designed for maximum strength and lightness.

A table leg is acted upon as a column by a top load, and when dragged across the floor it is acted upon as a cantilever beam by a side load. The side load is about one-half the top load, being governed by friction. Since the side load may be applied in any direction, the cross-section of the leg should be circular. For lightness and strength, the cross section should also be hollow. Since the loading is a combined column and bending action, the ideal solution is not a cantilever of equal strength throughout, but a cantilever of equal stiffness throughout. Structurally this calls for a member whose elastic curve has an equal angular displacement throughout its length. This is an arc.



From a rather lengthy mathematical derivation, formulas for the dimensions of the table leg are derived as

$$D = 0.598\, y^{\frac{1}{2}}$$
$$t = 0.054\, D$$

These equations describe a table leg 28 in. long, made of 17 ST aluminum alloy where D is the outside diameter of the tube in in. at a distant y in. from the floor. The thickness of the tube is t in. at D diameter. This leg will weigh about 10 oz., will support a dragging load of 220 lb. and a stationary load of 1,000 lb. The shape of the leg is shown in the diagram, as are the fittings necessary. The leg can be formed to a tapered tubing with control of wall thickness as described in PRODUCT ENGINEERING for September 1940, p. 400-403. —HERBERT STEVENS

Bantam, Conn.

Equinoxial Problem Misstates Sun's Diameter

To the Editor:

I am pleased to acknowledge my Equinoxial Problem published on page 564 of PRODUCT ENGINEERING for October. May I call attention to a statement of the problem which is somewhat in error. The sun's diameter is given as 80,000 miles instead of the 800,000 miles which I believe was the figure I submitted and which is considerably closer to the accepted value of some 866,000 miles. —ROLAND W. ZIEGE

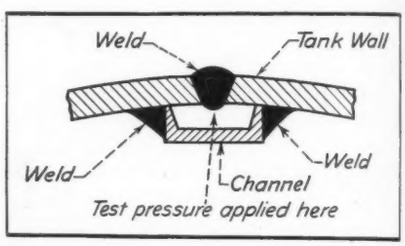
Central Scientific Co.

Double Welded Joint Simplifies Tank Testing

To the Editor:

This unique method for testing large tanks under pressure was called to my attention the other day. The method can be applied in many similar cases.

Welded seams in large oil tanks, such as for a transformer, which must not show oil seepage even over long periods of time, are often tested under pressure. Test pressures greatly in excess of those



for which a large tank can be constructed are desirable. A test with 150 lb. per sq.in. of nitrogen has been found good practice to insure the quality of the joint. The double joint shown here is now used by Allis-Chalmers to insure oil tightness and to simplify testing, only a small volume of nitrogen being required. —ED WEST

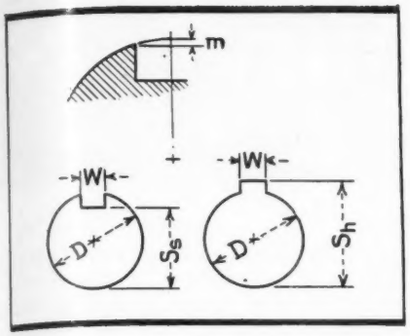
Chicago, Ill.

Method for Determining Keyway Dimensions

To the Editor:

I have recently worked out a method for determining dimensions for keyway depths which I think is far easier to use than the existing methods.

It is considered good engineering practice, when dimensioning keyways, to give the distance from the bottom of the keyway to the opposite side of the shaft for keyways in shafts and to the opposite side of the bore for keyways



in hubs. To determine these dimensions involves first the finding of the value of m, as shown in the diagram. Often tables are not available or do not include the value of m for the shaft and keyway in question. To calculate this distance requires the use of a table of squares and interpolation which is quite inconvenient.

A simple yet accurate method to determine this value of m is to square one-half of the key width and divide by the diameter. This method may be used for any size shaft providing the keyway width is equal to, or less than, the standard one-quarter of the shaft diameter.

The inaccuracy involved is only +0.0015 in. for a 6 ft. dia. shaft with a 1½ in. wide keyway. This inaccuracy decreases proportionately as the shaft diameter and keyway width decreases. This method may be used for square or flat, straight or tapered keyways.

Example: Determine the value for S_s and S_h for 1½ in. wide keyway in a 6 in. dia. shaft.

$$m = \left(\frac{W}{2}\right)^2 \times \frac{1}{D} = \frac{3}{4} \times \frac{3}{4} \times \frac{1}{6}$$

$$= \frac{3}{32} = 0.09375 \text{ in.}$$

$$S_s = (6.000 - 0.750) - 0.094 = 5.156$$

$$S_h = (6.000 + 0.750) - 0.094 = 6.656$$

Note: For shafts under 6 in. dia. and keyway widths equal to or less than one-quarter of the shaft diameter, the value for m will always be less than 0.100 in.

—Howard C. Kane
Kenmore, N. Y.

Ammeter Finds Errors In Design of Machine Drives

To the Editor:

Oftentimes engineers working on a new machine, or a redesigned one, are puzzled as to the freedom of motion of the various parts—whether excessive loading caused by friction, close gearing, clutch tightness, etc., is making the machine act improperly. The method we use is so obvious that it is usually forgotten—the ordinary electric ammeter. A few examples will make the point clearer:

1. We redesigned a 72-in. openside planer crossrail, changing the method of feed and the lift mechanism. It was figured that a 5-hp. d.c. motor was more than ample to lift the crossrail. When in place we found that instead of taking 5 hp. (20 amp. at 230 volts), the motor took over 80 amp. By changing the design of two thrust bearings the ammeter showed 18 amp.

2. A large newly designed multispeed gear box was set up for test. Maximum loss of 2 hp. allowed. A 7½-hp. variable speed d.c. motor was belted to the input end. An ammeter placed in the line indicated a 5.5-hp. load. The head was immediately removed and after a thorough investigation, an excess shoulder allowance (draftsman's error) was found to be causing great friction. The gear box would have been ruined if allowed to run for a longer period as the shaft and bearing could have reached red heat with no external sign.

3. An excellent example of economy was recently discovered by this means. A medium size newly designed shell turning lathe was being tested. A 40-hp. rating was called for. The latest type gearing and bearings had been installed. An actual high speed production test with the ammeter in the line showed that 15 hp. was the most the lathe could "consume." A 25-hp. motor is now recommended with a saving of material, a saving of expense, and a proved improvement in design.

"Clamp on" meters were found to be most convenient, particularly those with the switches for changing full scale readings mounted on the handle.

—Samuel Heller
Chief Engineer
Consolidated Electric Motor Repair Co.

Who Knows A Solder The Color of Bronze?

To the Editor:

We would appreciate your advising us where we can obtain solder that has the same color as bronze. We would like to use this to fill up blow holes in castings on finished and unfinished surfaces that are "in the air". This solder will be used to fill these holes for the purpose of appearance only on surfaces subjected to no pressure whatsoever.

—T. W. Kelley
Watertown, Mass.

Can You Work This One?

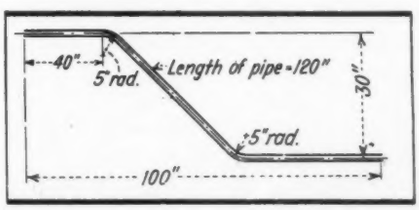
H. E. SMITH

This month's problem—

This One's A Pipe

A disconsolate plumber sat on the edge of a trench with a piece of pipe and a problem. It seems he had to bend an offset in the pipe to cross from one side of the trench to the other. The pipe was 120 in. long and he couldn't cut it. The length of the trench he had to work in was just 100 in. and the amount of the offset was 30 in. on center lines of the pipe. The pipe bender he had would only bend on a 5 in. center radius. The I.D. of the pipe was ⅞ in., the weight of the pipe was 0.57 lb. per ft. and at the time of making the second bend the wind was blowing from the N.E. at 37 mi. per hr. The designing engineer had given the location of the first 5 in. bend as starting 40 in. from one end but had left off his drawing the location of the second bend.

Where should the second bend be made?



Solution to November problem—

Brain Testers

1. A number whose double is half the reciprocal of the 6th root of 5 to the 8th power divided by itself, is ¼. This is easily found if it is realized that a number divided by itself is 1.

2. A practical method for cutting a watermelon through its major axis, such that each of n disk-shaped slices have the same volume, is to measure the total volume of the melon by determining the amount of water it will displace and then mark the points for cutting equal volumes as it is lowered into the water a second time. Mathematics may give a neater determination, but this method is good for a melon which is not a perfect prolate spheroid.

3. If there were 22 birds and 14 beasts in a menagerie, the lot would have 36 heads and 100 feet.

News and Summaries

Chromium Situation Warrants Cautious Optimism

ALL AUTHORITIES agree that a well-managed chromium situation should prevent an acute shortage in this country despite any contingency that might arise in the next two years. When it is considered that almost all of our chromium comes to us over the world's war-torn oceans it is obvious that contingencies have a wide field.

The amount of chromite ore we import (600,000 long tons in 1940) is sufficient to keep up with military and civilian needs even though these may grow somewhat in the future. The facilities for manufacturing ferrochromium have also been expanding and are becoming capable of keeping up with consumption. Hoarding and priorities in chromium till now have had the effect of creating a stock-pile large enough to give the country time to work out any problems caused by future importing shortage.

Imports of chromite may be divided roughly as follows:

Africa	43%
Philippines	24%
Cuba	8%
Turkey	11%
New Caledonia	6%
Others	8%

All but 8 percent of our imports may be considered as vulnerable. Domestic production is but a fraction of one percent of consumption although intensive development may raise that to nearly two percent within a year. American chromite deposits are chiefly in California and Montana and in the latter state two new plants (mines and smelters) are scheduled to begin production by January. They are owned by the Defense Plant Corporation and will be operated by the Anaconda Copper Company.

How far this country may be able to supply its own chromite is still a matter awaiting the results of geological surveys although it has been stated that the United States produced 40 percent of its consumption during 1918. Alaska has revealed some high-grade ore. Ores of lesser quality have been found in Montana, Wyoming, Washington, Oregon and California.

The quality of the chromite ore determines its industrial use in one of the three divisions, metallurgical, refractory and chemical. Only the high grade ore, containing at least 45 percent chromite and low in impurities, can be used metallurgically, that is, in the making of stainless steels and chrome-bearing steels for armor-piercing projectiles, gun parts, springs, axles and so forth. (The chromite is generally converted into high- or low-carbon ferrochromium in an electric furnace before being added to the steel.) Almost 50 percent of total consumption goes into the making of steel alloys.

Chromite with the proper physical and chemical (not high grade) properties is used for refractories in lining steel furnaces. Lump and ground chromite and cements using chromite are employed in bricks and in building and repairing furnaces. Another possible use of chromite is in the making of open-hearth furnace roofs. Use of chromite as a refractory accounted for about 30 percent of total consumption.

The remaining 20 percent of domestic consumption is absorbed by the chemical industry. Chromite is used in the manufacture of chromic acid and in making pigments such as yellow, green and red. It is also used in tanning and in making dyes such as olive drab. Recently chromium chemicals have been used increasingly in pickling solutions in the non-ferrous metals industry.

Conservation of chromium by substitution is impossible in stainless steels and, in tool steels, is blocked by the fact that the substitutes are even more scarce. Substitutes for refractories are

Badly torn metal of aluminum self-sealing fuel tanks, ripped in tests by .50 cal. machine-gun bullets, could prevent closing of their internal rubber seals. This long-standing design problem may be solved by Plioform, a new Goodyear product which will not flare or burst under crash impact, making it ideal for combat or training purposes. The new plastic is a military secret but Goodyear describes it as a compound of crude rubber and rubber resin.

difficult for the same reason and for many chemical purposes alternatives are unacceptable. Thus free oceans, adequate shipping and careful use are needed to keep chromite consumption close to normal now and in the future.

New Test for Flow of Solid Metals

UNDER HEAT AND STRESS, solid metals will flow or "creep." Metals such as lead creep at room temperatures but even steel will creep under the right conditions, such as might be met, for instance, in a steam turbine. Both turbine efficiency and creep rate go up with temperature; hence the importance of research and research methods in creating new high temperature alloys.

Usual creep tests are made on bars of metal kept in furnaces at from 800 to 1,400 deg. F. and require from one month to one year. The new test, devised by the General Electric Company's Research Laboratory, uses a thin wire heated electrically to between 1,500 to 2,000 deg. F. To prevent the rapid rusting that would take place in oxygen-bearing air, the wire is enclosed in a glass tube through which nitrogen flows. A hanging weight produces the stress and the resultant stretch is watched and measured through a microscope. Lengthening may be as much as ½ percent per hour and months of data are accumulated in one or two days. Interesting results and new theories are being produced by this method.

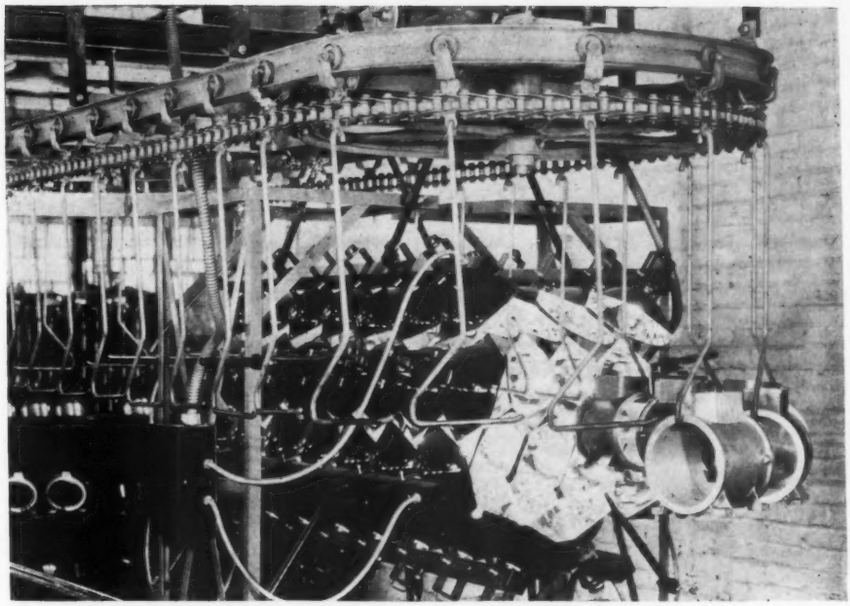
Rapid Qualitative Analysis of Steels

A QUICK AND SIMPLE METHOD for making a qualitative analysis of any steel sample was reported recently by the Bell Telephone Laboratories. Uniting chemistry and electricity, it is called electrographic analysis. The equipment is inexpensive and the records are permanent.

This is a useful application of the sometimes destructive principle of electrolysis. When an electric current is passed through steel and into a solution of a salt or alkali or acid, some metal is always carried into solution. For this test the minute amount of metal needed has no effect on the object tested.

Since various metals react with different chemicals to give colored compounds that are easily recognizable, it is possible, for example, to use potassium ferrocyanide to produce a blue color with iron or a brown color with nickel. Chemicals are available for the individual testing of practically every metal commercially used.

A simple test may be carried out by placing a piece of filter paper soaked in the desired test chemical, plus a bit of some salt solution, between a piece of metal used as the negative pole and the metal under test, used as the positive pole, and applying about 6 volts for a few seconds. The filter paper should then show the desired color or colors. By this means metals and their alloys can be identified and platings or coatings on metal may be inspected for pinholes with no noticeable damage to the piece being inspected.



Infra-red heating raises these aluminum frames to 150 deg. C. for shrinkage fit with wound stator. Used at the Lima, Ohio plant of Westinghouse, the conveyor moves frames 30 ft. a min. through a tunnel formed by 56 lamps, each 375 watts. This method replaces the press fit which caused scoring when too tight or heavy scrap losses because of loose fitting parts.

Lighter Paint For Machine Tools

A NEW AND LIGHTER SHADE of "machine tool gray" has been selected by the National Machine Tool Builders' Association as the future standard finish for machine tools. Its adoption came as the result of a report to the Association proving that both the users and builders of machine tools preferred the lighter color. There is no compulsory date of use, however, as each builder is allowed to make the change when it best suits himself and his customers.

The new lighter shade will show up dirt and fingerprints more easily but this factor is outweighed by the much desired factor that better light reflection will be obtained. One early user has reported a ⅓ increase in the light on the working plane.

The new paint is already available from paint manufacturers for spraying or brushing.

Do You Know That—

FURNITURE DRAWERS are designed for most efficient use of space. Dresser drawer dimensions are difficult to standardize because of variations in the way laundries fold shirts. In Chicago, shirts are folded to a length of 17½ in.; this length varies in other regions. (64)

YELLOW FOG LAMPS are no better at piercing fog than the light of an ordinary tungsten lamp, recent experiments show. (65)

HUMAN HAIR is the humidity element of radiosondes, weather-reporting instruments which are carried up by balloons to high altitudes. The hair must be blonde, must never have been dyed or burned by curlers, and it must be 18 to 22 in. long. (66)

RADIO is now being used to balance automobile crankshafts accurately. The radio balancer tunes in the most minute vibration and then automatically corrects it by drilling away a tiny portion of metal from exactly the right spot. (67)

ENGINEERING IN WASHINGTON

McGRAW-HILL WASHINGTON BUREAU, *PAUL WOOTON, CHIEF*

Design of the Kearny is praised by Navy officials, who have no record of any other destroyer being hit in such a vital spot and then proceeding to port. The Nazi torpedo opened the hull at the boiler room and ranged up through the superstructure, half severing the vessel. The Kearny is one of a series built several years back, whose c.g. was erroneously placed so high that they listed badly in fast turns. Navy was seriously criticised; its department of construction and repair was later abolished, partly for that reason. But the Kearny incident seems to clean the slate.

A mobile machine record unit has been developed by the Army. Complete records of all officers and men are kept on small cards, together with a half dozen sorting and classifying machines —all in a trailer truck. All pertinent facts of each man's record are punched in the cards. If a raiding party captures a dozen cooks from a division, for example, the cards run through at the rate of 400 a minute, and out pop the cards of all the men who are qualified to cook.

American Rocket Society's president, H. Franklin Pierce, suggests rockets as effective anti-aircraft barrage at maximum airplane altitudes. These would be fired from troughs and would save the expense and time of locating AA guns. Mr. Pierce, writing in the *Military Engineer,* says that his objective can be realized through substantial research. Army officials, questioned as to their interest, had no comment, but it can be assumed they are investigating. Also being studied is the proposition of un-manned, radio-guided torpedo planes.

Every time the British meet the Italians at sea they keel-haul them so badly that rumors now say the Royal Navy has a secret weapon. This would be the radio locator, now in wide use in England against invading air forces. This device, you may recall, makes use of the micro-wave band of the radio spectrum. Waves in this band are short, approaching those of visible light which can be focused and reflected. The locator, sweeping the sea or sky, gets back a reflection from whatever object it encounters within its range. Technicians here have no comment, except that radio detection at sea might be possible. British officers, talking off the record in Washington, have said to this writer that their only problem concerning the Italians aloft or afloat, has been to find them.

Buck Rogers engineering succeeds so often, under the impact of war, that one must risk being linked with screwbox theory to make sure of not missing something important. For instance the Navy, in a solemn report not long ago, recommended against torpedo boat-carrying ships for several reasons—among them that such boats would not be practical in the rough water of open sea. Now, the experts are saying that high waves are just the thing for the suicide boys to hide behind.

They laughed, in austere aviation circles, when the "rocket" impulse motor was urged for immediate war use. In fact this writer was shushed by a high-octane editor for wasting verbiage on the subject. Now, one of the Government's big military laboratories is burning the midnight kilowatts to get a rocket job aloft quick.

Another example is the all-wing plane, extensively developed 20 years ago and kept on the shelf most of the time since then. John Northrop, who did the job in 1923 and now is back on it again, says that in the interim small opportunity was afforded him to forge ahead. Now his one-man flying mockup has been up 300 hours, performs well and he is estimating that the all-wing principle will improve all around airplane performance by 25 percent and cut manufacturing costs by about 50 percent. If he is right, the dreamers and the realists have both been asleep.

Northrop's all wing plane is about the size of a current pursuit job; is all wing except for the two pusher engine nacelles, and retracts its three landing wheels.

The air-cooled 80 h.p. in-line Franklin engines are buried in the wing, cooled by air from vents in the leading edge, and are coupled by shafts to the propellers well back of the trailing edge. Almost all of the machine is lifting airfoil, whereas the fuselage and empennage of the conventional plane is non-lifting (except that the horizontal fin lifts the tail) and the entire weight and drag is parasitic, if Mr. Northrop is right.

Elimination of all but wings saves weight, saves drag, saves materials and costs, and adds to speed. The additional speed actually will show up as a given speed with less power, or operating economy. The known critical velocity of airfoils will apply to the all-wing principle as well as to conventional planes. That is one limitation. Another is that pilots have about reached their endurance limit in turns and in dive recoveries. But in the case of transport operators, the limiting factor is economy, and Northrop's possibilities have exceptional interest to them.

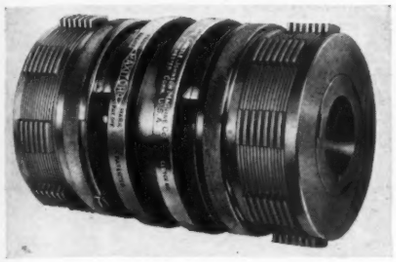
Northrop's figures show that the minimum dimensions of an all-wing plane, to get appreciable all-wing advantages, should be not much less than those of a medium bomber. There are important aerodynamic considerations, but one reason for this minimum is that he needs a wing thickness of six feet or so for people to stand up in. (An all-wing plane must carry all of its cargo in its wings, of course.) In really big all-wing ships, of the Army B-19 and Navy XPB-2M-1 caliber, the wing would accommodate not just one deck, but two.

And now tank destroyers. The Army has announced a Tank Destroyer Tactical and Firing Center, to carry on experiments in destruction of armored forces. Army has only one anti-tank battalion as yet. This unit has 54 destroyers, of two types. One is a half-track (track-layer at rear and wheels in front) vehicle, mounting a 75mm gun, which can stop anything that can move on land. It carries a crew of four, and two-way radio equipment. The other is a wheeled carriage mounting one or more 37mm shell guns. A 37 is bad news for light tanks but mediums often get away from it. The French 75, or the U. S. three-inch field piece will stop any tank, but they must halt and unlimber for action. A tank destroyer is simply artillery on wheels which can shoot on the run.

New Materials and Parts

Floating Plate Clutch

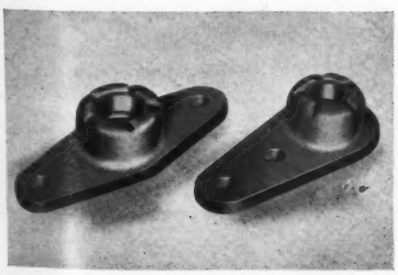
This multiple-disk clutch is said to have several special features. It may be assembled or disassembled manually, can be adjusted for wear manually, and its engagement is controlled by light



pressure. Known as the "Maxitorq" clutch, it is so built that a separator spring holds apart each pair of inner disks when the clutch is disengaged. Such Floating Plate construction reduces to a minimum any drag, abrasion or heating encountered while disengaged. The clutches are available with all disks of hardened steel for use with lubrication, or with alternate disks of steel and self-lubricating bronze. Clutches come in single or double type and in sizes varying from ½ hp. to 3 hp. at 100 r.p.m. Carlyle-Johnson Machine Co., Manchester, Conn.

Anchor Type Stop Nuts

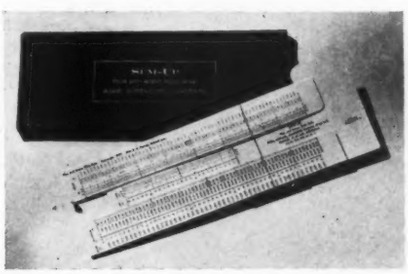
Designed to provide vibration-proof fastenings for removable plates used to cover hand holes, access and inspection openings, and for other blind mounting attachments, anchor type Elastic Stop Nuts are permanently riveted to the inside of the structure. The bolts, which are inserted from the outside, pass first through the removable plate, thence through the structure into the stationary nuts. The fiber locking collar,



which is an integral part of each nut, prevents the bolt from becoming loose after it is installed regardless of the severity of the vibration to which it is subjected. The bolts may be removed and replaced many times, the anchor nuts retaining their locking ability because of the resilience of the fiber collar. These nuts are offered in a wide range of sizes, materials and thread systems. Elastic Stop Nut Corp., 2332 Vauxhall Rd., Union, N. J.

Sum-Up Slide Rule

Claimed to be a great time saver in making and checking calculations for mechanical drives, laying out machine shop jobs, making patterns, and for many types of work that require converting millimeters to inches and inches to millimeters, this new Sum-Up slide rule adds, subtracts, and converts fractions of an inch, decimals of an inch and millimeters. The rule is made of celluloid, is easy to learn to operate, and has sufficient accuracy for most practical problems of adding, subtracting or converting. Sum-Up Slide Rule Co., 114 Liberty St., New York, N. Y.

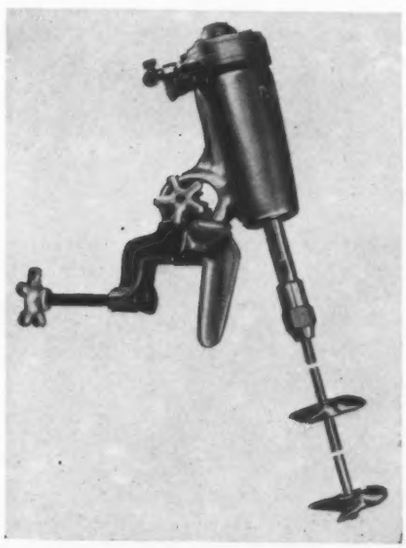


Wood Fiber for Industrial Use

Wood fibers which have been available basically as insulation material in the form of blanket, bat and insulating fibers are now available for industrial purposes. These fibers can now be made to rigid specifications as to size, quality, chemical content and physical appearance. They can also be made of varying types of wood or in a multitude of combinations. Fibers may be asphalt treated, or may be chemically treated so as to be fire-resistant or water-proof, or may be processed especially in accordance with manufacturers' requirements. Such fibers are available for filters, packing pads, plastics and other purposes as well as for insulation. Wood Conversion Co., First National Bank Bldg., St. Paul, Minn.

Air-Driven Mixers

Two new propeller type mixers, incorporating air-driven motors, are the first units of this type offered by the manufacturers. The turbine type air motor used in these two mixers is especially designed for agitator duty and features a built-in muffler for quiet operation and a low rate of air consumption. The mixers are built for operation at air pressures of from 60 to 120 lb. with the optimum between 70 and 90 lb. Other features include a quickly removable shaft for easy cleaning, adjustable shaft length, and sturdy con-



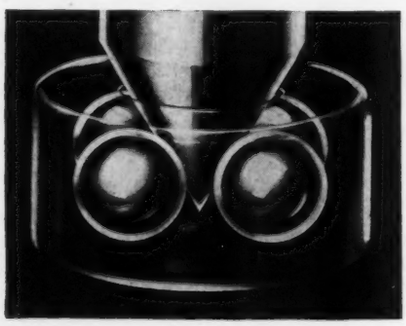
struction with extra ball-bearing removing whip-load from the motor bearing. A universal clamp permits mixer to be used at any angle in the tank, thereby providing intentional vortexing, mild swirl, or rapid bottom-to-top turnover. A throttle permits varying speeds to match each mixing operation. Model AR-25 operates at 1750 r.p.m. A 36-in. shaft with 3 in. propeller is standard. Weight is 25 lb. Model AR-33 operates at 400 r.p.m. and comes equipped with a standard 36 in. shaft and 7 in. propeller. Its weight is 29 lb. A full range of metals and alloys for shafts and propellers permits use in any liquid while, for special applications, complete line of accessories is available. Mixing Equipment Co., 1038 Garson Ave., Rochester, N. Y.

White Tracing Cloth

Because of its high degree of transparency and its special processed velvety surface, the new No. 123 Whitex tracing cloth is claimed to give "inkline" density with hard pencil. It is tough, durable, and will not discolor with age. Its glossy "stay clean" back is an added feature and its extra transparency adds speed to print production. Whitex also erases quickly and cleanly with art gum and soft erasers, and erasures do not show on the blueprint. Detail does not smudge or rub off. Whitex takes colored pencils sharply and cleanly. Frederick Post Co., Box 803, Chicago, Ill.

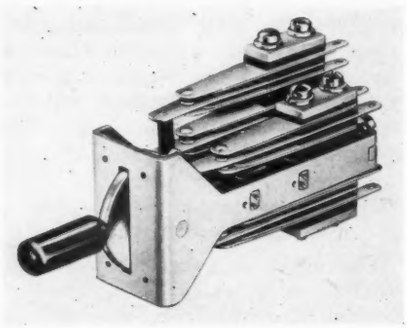
Miniature Bearings

Now regularly supplied is this first of a pivot bearing series by this manufacturer. This miniature bearing has an outer diameter of 5 mm., and a width of 2.5 mm. It is made of high-carbon chrome bearing steel, hardened and highly finished on raceway and exterior surfaces. Depending on speed, thrust load ratings run up to 1.5 lb. and radial ratings up to 0.6 lb. Pivots can be supplied if necessary. Miniature Precision Bearings, Keene, N. H.



Lever Switch

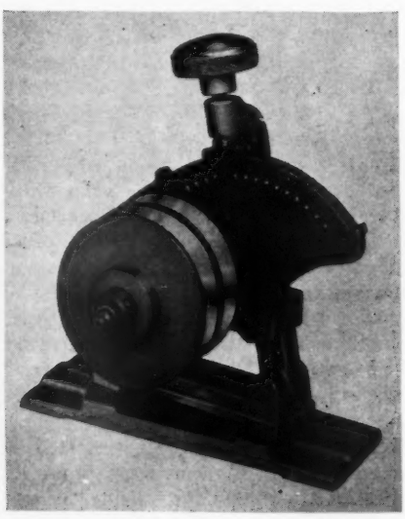
This new Series 4101 Lever Switch is constructed to meet the need for a heavy-duty, multiple contact, positive action, lever type switch. It is available in an almost unlimited series of combinations of contact assemblies and can be had with either locking or non-locking action. Contact assemblies are limited to 36 springs per switch. Contacts are riveted to nickel plated phosphor bronze springs, and ample wiping action assures clean contact surfaces. Standard



contacts are of $\frac{3}{16}$ in. dia. silver and are rated at 10 amp. at 110 volts, a.c. Extra heavy contacts of 20 amp. capacity can also be had. Donald P. Mossman, Inc., 6021 N. Northwest Highway, Chicago, Ill.

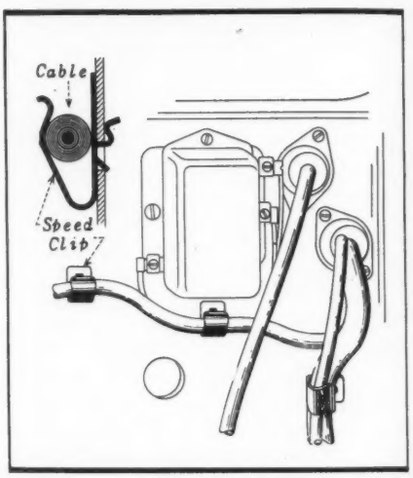
Variable-Speed Transmission

The JFS-CUB, a new variable-speed control, is especialy designed for all "A" section V-belt applications and for speed ranges up to 3.3 to 1. Smooth sided pulleys are used rather than the interlocking type. Among the advantages claimed are: positive belt alignment which makes possible the mounting of the CUB in any position without impairing function, machined and balanced cast iron construction, forced lubrication of the special bronze pulley bearings and free-end pulley spindle to permit easy installation of belts. This drive is designed to transmit full capacity of "A" section V-belts, and can be used on all machines now using that size. Standard Transmission Equipment Co., 416 W. 8th St., Los Angeles, Calif.



Assembly Clips

For rapid and vibration-proof assembly of cables, wires, rods, conduits or tubes, these new Speed Clips have now been made available. They eliminate any need for nuts and bolts, washers, special brackets or clamps, allowing the entire assembly to be made from one side. No tools are necessary for installation. The clips can be inserted into round holes and snapped into place by finger. Then the cable is in turn



snapped into the spring arms. Speed Clips of this type are also available with rubber or Neoprene coating on the upper arm to protect tubing or wire. Brought out as an aid to speedy production and reduced assembly costs, they can be had for cable diameters of $\frac{1}{8}$ to $\frac{3}{4}$ in. and for sheet thicknesses of from 0.050 in. to 0.119 in. Tinnerman Products, Inc., Cleveland, Ohio.

Portable Coolant Pump

Outstanding features of this coolant pump system are its portability, easy control of coolant flow by twist of a wing nut, capacity to withstand continuous operation, ease of replacement of all wearing parts, ability to handle coolants of all but extreme viscosities, and an easily cleaned strainer. The pump comes with all necessary fittings to attach it to the machine tool, plug into the electric line and put it into operation. It is particularly recom-

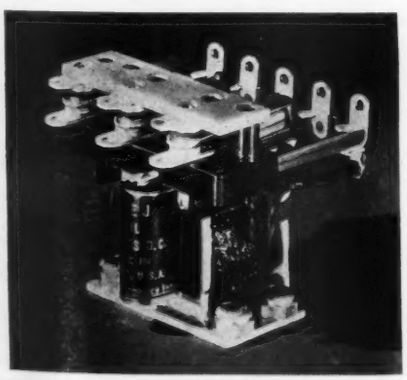
mended for drill presses, lathes, small mills, grinders and similar machines. For machines not already equipped for use of coolant, standard accessories are available. Gray-Mills Co., Inc., 215 W. Ontario St., Chicago, Ill.

Synthetic Rubber Hose

Another successful application of Ameripol, the new synthetic rubber, is its use in this new type hose for all standard paint and lacquer spraying equipment. The new hose replaces the lacquer hose and paint spray hose previously manufactured by this company. It is made of a black, oil-resistant compound with a maximum working pressure of 150 lb. in all sizes. It may safely be used as air hose. The new hose comes in ¼ in. to ½ in. I.D. The B. F. Goodrich Co., Akron, Ohio.

Relay

Of small size and low weight, the new Type "J" relay is of rugged construction. Suitable for use at high altitudes, it is designed to withstand aircraft vibration, high acceleration, and will operate satisfactorily under conditions of high humidity. Contact points



are self-cleaning due to wiping action. Coils are designed for operation on direct current, and are particularly suitable for aircraft voltages. Overall dimensions of this relay are: 1⅞ in. high, 1⅛ in. long, and 1⅝ in. wide. G-M Laboratories, Inc., Chicago, Ill.

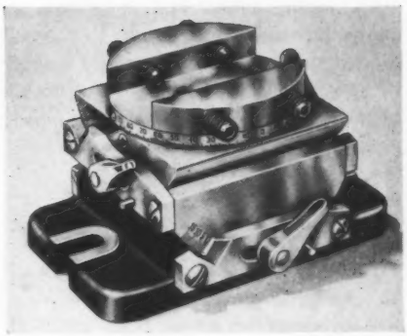
Simplified Lubricator

This new type sight-feed lubricator for air-driven equipment operates successfully regardless of its position in the line. Because the new type lubricator has no baffle, it can be turned to any position convenient for visibility.

Another feature of the new positive-action Roto sight-feed lubricator is that it requires only a single regulating valve instead of the three separate valves used on previous types. Oil is added by removing a simple screw plug at the top of the lubricator. These units are intended for installation in an ordinary tee in the air line. They are made in ⅘ pint and quart sizes, and can be regulated to drop as few as 5 drops of oil per min. The Roto Co., 145 Sussex Ave., Newark, N. J.

Tool Vise

Designed for grinding chip-breaker grooves into the tips of carbide tools, this any-angle tool vise has now been placed on the market as a separate unit. This new vise is constructed on a double-cradle principle, permitting adjustment of grinding angles on three separate planes. Two closely machined steel blocks, rounded on the bottom, are cradled into each other at right angles. After adjustment, they are locked together by tightening cam locks operating in machined segments at ends of the respective blocks. Mounted atop



these two blocks is a flat circular piece which swivels 90 deg. from center of any of the four sides of the block immediately below. This piece carries the vise jaws, holding tools firmly by means of Allen screws. The closely fitting steel blocks permit no vibration or deflection, thereby assuring maximum accuracy of the grinding angle selected. Each block is clearly marked up to 15 deg. either way from horizontal and this adjustment, combined with 360 deg. selectivity of the circular piece at the top, provides almost any angle desired. Hammond Machinery Builders, Inc., 1624 Douglas Ave., Kalamazoo, Mich.

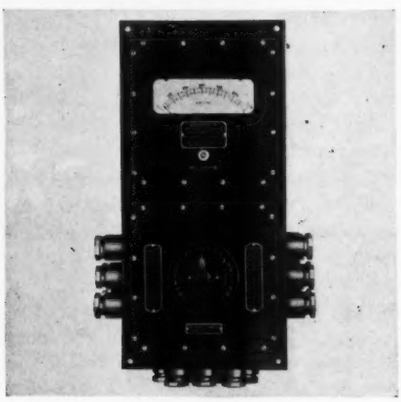
Timing Relay

The Duraflex timer is designed to meet the requirements of control instruments for industrial processes and machines. It contains a self-starting synchronous motor and employs a toothed clutch to prevent errors due to slippage. Time settings remain fixed for repeated time intervals until the time set knob is turned to a new setting. Errors are held to less than 1 percent of the time scale. Two scales are available; a 2 min. and a 20 min. scale. The silver contacts open with a snap action and are rated at 1,000 watts

non-inductive load. The timer is normally furnished with a pressed steel cabinet for surface mounting but can be had with flanged cabinet or without cabinet for special mountings. Eagle Signal Corp., Moline, Ill.

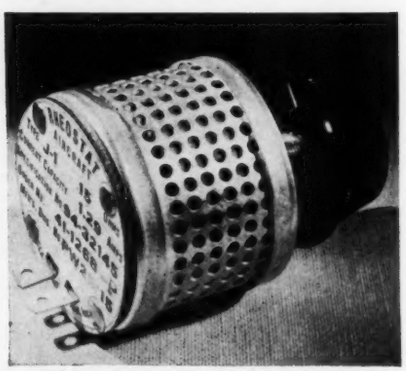
Diesel Engine Pyrometers

Just announced is this new line of diesel engine pyrometers which are especially designed for all types of naval craft. These pyrometers are equipped with high resistance millivoltmeter movements having automatic cold-end compensators. They are highly damped to withstand excessive vibration. The instruments are housed in welded steel, drip-proof cases. The thermocouple switches are of the rotary type with double contacts made of laminated phosphor bronze and are intended to take care of the various diesel engine requirements. All parts are designed to meet the latest naval specifications. The Bristol Co., Waterbury, Conn.



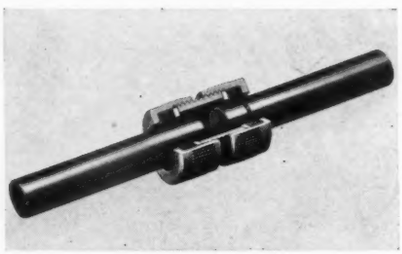
Armored Rheostat

To withstand exceptionally hard usage, particularly where the unit is exposed, this armored type of power rheostat has become standard equipment in several types of fighting aircraft. It is mounted in a perforated metal housing and flat lug terminals are brought out at the rear of the casing. A $\frac{3}{8}$-in. bushing and nut provide a one-hole mounting. An insulated metal core is employed to support the winding which is embedded in a special inorganic cement. Maximum heat dissipation is obtained even when a portion of the winding is cut in. Even at one-third total resistance, the unit dissipates a full 25 watts. Units are available in standard resistance values of 1 to 5,000 ohms, and other values on special order. Clarostat Mfg. Co., 285-7 N. 6th St., Brooklyn, N. Y.



Flexible Coupling

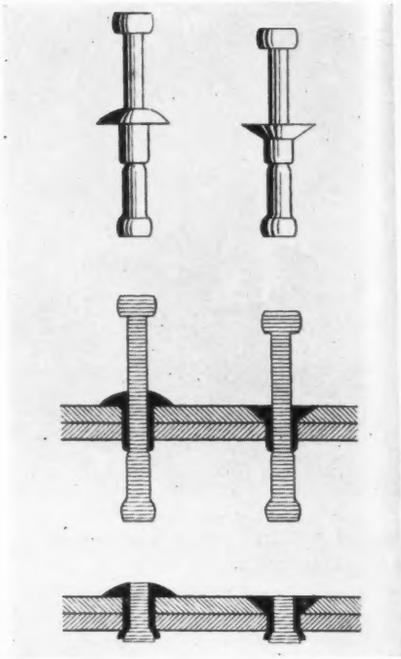
Joining the rest of the "Torflex" line, the new Type D flexible coupling is not only capable of transmitting torque and compensating for misalignment but



can serve as a connecting medium for oil lubricating lines as well. No special shaft preparation is needed, and the couplings can be used as replacements irrespective of the previous preparation of the shafting. Any size between $\frac{1}{4}$ in. and $\frac{5}{8}$ in. can be handled. Grooving the drive shaft to a depth of $\frac{1}{8}$ in. is all the preparation required. The couplings can be preassembled or can be put together on the shaft. Torque capacities range up to approximately 45 lb.-in. at recommended usages. Harris Products Co., 5428 Commonwealth Ave., Detroit, Mich.

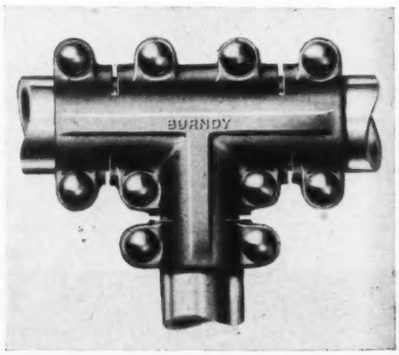
Blind Spots

One of the most recent cures for blind spots in airplane riveting is this self-plugging rivet which has a mandrel with an expanded section and head on the blind side. This expanded section is pulled into the hollow member, expands the shank, and forms a tulip head in the back. This operation can be performed with either a hand-operated or automatic gun of which several designs are available. The outside end breaks off during the application and can be trimmed flush with ordinary nippers. When a pull of 300 to 900 lb., depending on rivet size, has been exerted on the mandrel, it creates a clinching action, holding the sheet securely together. It also expands the shank of the rivet, causing a pressure fit of the shank. Aircraft factory tests show this type of rivet can be applied and trimmed at the rate of 540 an hour by one unskilled operator. Automatic guns for heading the aluminum rivet are also available. The Cherry Rivet Co., Los Angeles, Calif.



T-Connector

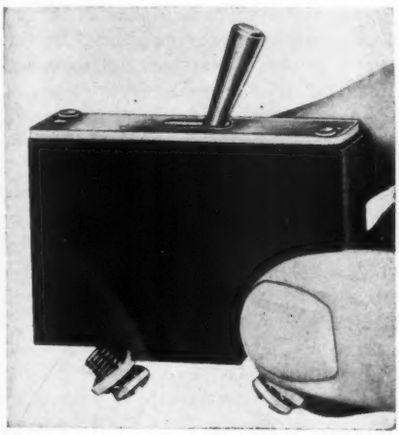
The Type NST is a high copper alloy multigraphed type T-Connector for tubing, run and tap. It is slotted between bolts to provide independent high pressure areas of contact. Everdur oval-



shank bolts are readily installed with only one wrench. This connector effectively combines the function of T-connector and coupler at a single point. It is finished to provide maximum contact resistance. Available sizes accommodate from $\frac{3}{8}$-in. iron pipe size to 6 in. on either run or tap. Burndy Engineering Co., Inc., 459 E. 133rd St., New York, N. Y.

Circuit Breaker Switch

Circuit protection as well as switching is offered to the aircraft trade in the Class 9300 Circuit Breaker. This compact breaker saves space, weight and wiring time. It eliminates fuses and provides calibrated protection for each circuit, all within one sealed housing. For make and break the toggle lever is moved manually as with an ordinary switch. If dangerous overloads are present, the toggle lever snaps to the "off" position. To reset the lever is manually returned to the "on" position. Sizes from 10 to 50 amp. are available in the same inclosure, weighing only 2½ oz. Square D Co., 6060 Rivard St., Detroit, Mich.



New Resin

Poly-pale resin, derived from gum or wood rosin, is pale in color, free of metals and has a lower acid number and higher melting point and viscosity than any natural rosin. It is produced by the polymerization of the unsaturated resin acids in rosin. The new material seems particularly suited for the preparation of gloss oils, hardened rosin varnishes, ester gum, rosin-modified phenolic resin, rosin-modified maleate resins, metallic resinates, spirit varnishes and other protective coatings. The melting point ranges from 98 to 103 deg. C. and the acid number from 152 to 156. Many tests have shown no crystallization of this resin, making it useful for core oils and printing inks. Hercules Powder Co., Wilmington, Del.

Photocopying Equipment

This large contact photocopying unit is now being used in plants whose large increase in drafting work has made it necessary. The unit employs a photocopying process involving a horizontal

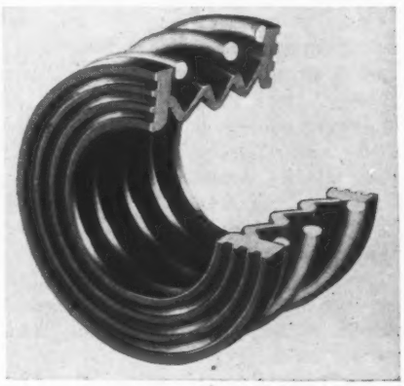
bank of both white and amber lights beneath a ground glass on which the sensitized paper and matter to be copied are held firmly in contact by high vacuum, created by a self-contained motor driven pump. It accommodates a 36 by 88 in. single drawing or permits multiple printing as shown. Variations to suit particular purposes are available from the manufacturer. Hunter Electro-Copyist, Inc., Syracuse, N. Y.

Welding Protective Device

Complete protection against heat or excessive current, or both, is provided by a new protective control device for arc welding machines just announced. The protective control device consists of two current transformers, (upper devices in illustration), the primaries of which are connected in series with the motor leads and the secondaries supplying power to operate two snap-action thermostats (lower device in illustration) which are mounted directly on the motor lamination. The thermostats, therefore, operate by means of heat conduction as well as by current passing through them. The thermostats reset automatically when the motor returns to a safe operating temperature or when the current is reduced. The Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio.

Water Pump Seal

This new bellows-type seal has only two parts: bellows and spring. The bellows is made of a synthetic rubber compound found to be superior for protection against grease, oils, salt water, alcohols and anti-freeze. The entire unit operates as a driving coupling. The seal itself does not touch the shaft; the spring holds the contact facings against the sealing washer on one end and the driving base on the other. Because of the seal's ability to flex and compress as a unit, pressure variation, misalignment for thrust, torque or vibration caused by an unbalanced impeller are accommodated or compensated for automatically. The serrated faces are said to be responsible for the positive sealing action. The seal is easily installed, both ends are identical. Crane Packing Co., 1800 Cuyler Ave., Chicago, Ill.



Metal Coating Compound

This new product, marketed under the name of AMCO Metallic Coating Powder, Brand "K," is designed to repair damaged tin coatings. While the finished coating has the appearance of tin and matches perfectly with the surrounding hot dipped tin coating, it is also completely rust resistant and will protect the underlying iron or steel as well as hot dipped zinc coating of the same thickness. This important property is due to the fact that, when in contact with iron or steel in a corrosive medium, it is electro-positive and therefore affords protection against rust and corrosion. It is intended for use wherever an original tin coating has been damaged, worn, or burned away in a welding operation. Because its melting point is lower than that of tin, the original coating is not melted or disturbed by the application. Since the finished job matches the tin, the compound may be used wherever appearance is a factor. American Solder & Flux Co., Trenton Ave. & Norris St., Philadelphia, Pa.

Books and Bulletins

Mechanical Engineers Handbook

LIONEL S. MARKS—*Fourth Edition. 2,274 pages, 4½x7 in. Red leatheroid flexible covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N. Y. Price* $7.

In this new edition is presented the more important data that has been compiled covering the technological advances made, since the previous edition, in the application, theory and classification of knowledge in the field of mechanical engineering.

Most of the sections have been rewritten in order to incorporate new data and contemporary engineering points of view. Much material that appeared in former editions has become or is in the process of becoming obsolete; such material has been excluded or condensed. Among the new subjects treated in the current edition are the theory of models, plastic behavior of materials, stress concentration, packings, wind pressure on structures, sound and noise, automatic control of processes, and powder metallurgy.

Fundamental engineering theories, experimental and test data, as well as records of performance are all presented in a manner such that the volume forms an authoritative, up-to-date, handy reference manual for any practicing engineer.

Electrical Reference

E. S. LINCOLN—*1,300 pages, 1,300 illustrations, 8½x11 in. Blue clothboard covers. Published by the Electrical Modernization Bureau 60 E. 42nd St., New York, N. Y. Price* $15.

This industrial-commercial reference book is indeed an encyclopedic volume in that it covers every branch of the electrical industry and several associated fields such as electrical shop equipment, drives, clutches and gears.

It is divided into 25 sections, each dealing with a separate branch of the industry. Each section begins with an explanation of the theory or practice involved. These explanations are practically texts in themselves but additional material is included wherever necessary to amplify the illustrations and descriptions of commercial products available. These informative examples, contributed by many manufacturers, give a detailed view of the scope of each field and are interspersed with discussions of the how and why of their use. Graphs, design tables, circuit diagrams and many electrical codes are included. In each of the 25 fields covered, including wiring, lighting, motors, furnaces and instruments, the explanation is written for the non-specialist in the field.

This volume should prove of considerable value to the maintenance engineer and designing engineer alike. Type and illustrations are large and clear; printing and binding are attractive. The book is well indexed.

Basic Units in Mechanical Drawing

RANDOLPH P. HOELSCHER and ARTHUR B. MAYS—*Volume I; Second Edition. 305 pages, 6x9 in. Tan clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price* $1.60.

Designed for the instruction of high school and technical institute students, this textbook is planned to be used in the drafting room rather than merely in discussion. The book is divided into two parts; each part has 17 units of study. Each unit in turn is divided into (1) purpose, (2) what you should know, (3) how to do it, (4) questions and (5) problems.

Elementary topics are set forth in the first units of the book, leading up to methods of orthographic projection, simple machine elements, sectioning, and the making of shop drawings. In this second edition many new problems have been added and new material has been added to some of the units. Map drawing has also been added.

Practical Solution of Torsional Vibration Problems

W. KER WILSON — *Second Edition, Vol. II, 694 pages, 5½x9½ in. Blue clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price* $8.50.

Completing the work started in Volume I, this companion volume presents further new design data and engineering methods for studying vibration problems peculiar to high-speed engines that are encountered in the marine, electrical, aeronautical and automotive fields of design. Of special interest to design engineers engaged in these fields is the author's comprehensive treatment of the various materials used in the construction of transmission systems. In this he includes a study of fatigue phenomena with special reference to the influence of discontinuities in causing stress concentrations.

In addition to a more inclusive analysis, than was contained in the first edition, of the determination of stresses caused by torsional vibration at resonant speeds in high-speed engine systems, other important subject matter has been brought up-to-date. The text which covers vibration measuring instruments has been thoroughly revised so that it now contains descriptions of the latest types of electrical measuring instruments with their theory and calibration. The subject matter relating to the theory of engine damping and the various devices used for damping has been completely revised. The volume now includes a separate chapter devoted to the rotating pendulum vibration absorber.

In the appendix is described a method for making an harmonic analysis of the exciting or damping torque curves of torsiograph records. To the bibliography has been added a list of British patents which relate to torsional vibration.

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Uses and Limitations of Radiant Heat For Baking Organic Finishes

G. KLINKENSTEIN—*8 pages, 8¾x11¼ in. Published by Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J. Available free.*

Design engineers and practical finishers interested in the radiant-heat, or infra-red, process of baking organic finishes, will find this reprint from *Metal Finishing* of interest. The publication discusses conditions for the efficient use of radiant heat baking, finishes for use with the process, and other matters of importance to the finisher.

Machine Tool Electrical Standards

12 pages, 8½x11 in. Mimeographed sheets. Published by National Machine Tool Builders's Association, 10525 Carnegie Ave., Cleveland, Ohio. Price $1.

The electrical standards recently adopted by the Association are here presented in full. Rules for wiring diagrams for circuits and motors receive considerable treatment and two full pages are included showing standard symbols. Circuit breaker construction and clearances are specified as are types of motors and conductors. Standards for wiring and grounding of machines are well covered.

HELICAL TENSION SPRING TABLES—II

PAUL KLAMP

THE FIRST OF THIS SERIES covered general considerations of quick spring method and included tables the use of which is described herewith in connection with the main selection Table B. The first section of Table B is given here. Similar sections will cover springs up to 3 in. O.D. with maximum wire diameter of $\frac{9}{16}$ in.

Table B is based on stresses that are 20 percent lower, according to usual practice, than those used in compression spring tables published in PRODUCT ENGINEERING, Aug., Sept., Nov. and Dec., 1939.

The load constant C, given in Table B for every O.D. and wire size combination, equals the safe table load P times the table ratio R and is the same for three stress groups. When P is modified to meet special requirements, C/P gives a new ratio to be used in determining spring length, l.

Table B is based on a torsional modulus of 11,500,000. Since hot rolled wire over ½ in. in diameter and stainless steel have a lower modulus, their table loads should be reduced 10 percent, but the ratios remain the same. Table B is based on close-wound springs, with or without initial tension.

Spring materials, corrosion, tolerances, high temperature operation, spring surge and frequency were discussed in the previously mentioned articles.

In the following directions, references are made to Tables A, C and D, and Fig. 1 in P.E. November, p. 633-4.

Directions for Spring Selection

A. SPRINGS FOR STATIC LOAD

Given: P and l (see Fig. 1)

Find: (1) Stress group in Table A, (2) spring O.D., d, P and R in Table B, (3) T in Table D, (4) $l_o = l\ R\ [R + (1 - T)]$, and (5) $P_o = PT$.

B. RECIPROCATING SPRINGS, WORKING LENGTH NOT SPECIFIED

Given: P_1, i and S (see Fig. 1)

Find: (1) $P = P_1\ i$, (2) D_t in Table C, (3) stress group in Table A, (4) a spring in Table B while checking mentally whether its RD_t will yield a satisfactory l_o, thus finding O.D., d, P, and R; (5) T in Table D, (6) $l_o = D_t$ R, (7) $D = D_t$ $(1 - T)$, (8) $l = l_o + D$, and (9) $P_o = T\ P$

C. RECIPROCATING SPRINGS, MAXIMUM WORKING LENGTH SPECIFIED

A maximum working length equal to or somewhat smaller than the given value is derived. By varying the hook length, exact requirements for spring length can be met.

Given: P_1, i, l and required P (see Fig. 1)

Find: (1) D_t in Table C and check to see that it is smaller than l. If not, a larger i is required. (2) Approximate $R = (l\ D_t) - 1$, (3) stress group in Table A, (4) T in Table D, (5) $D = D_t\ (1 - T)$, (6) required $P = P_1\ i$, (7) required $R = (l - D)/D_t$, (8) a spring in Table B with P the same as, or larger than the required load at l, and with R the same as, or smaller than required, thus obtaining O.D., d, P, and R, (9) actual l_o = table R x D_t, (10) actual l = actual $l_o + D$, and (11) $P_o = T\ P$.

D. SPRINGS WITH A DEFINITE SCALE IN LB. PER IN. DEFLECTION

If the load must be adjustable all the way down to zero, do not use any initial tension ($T = O$).

Given: Required P and scale in lb. per in. deflection.

Find: (1) D_t = required P/scale, (2) stress group in Table A, (3) a spring of equal or somewhat larger load than the required P, then its *O.D.*, d, and C, (4) $l_o = C$/scale, (5) T in Table D, (6) $D = D_t\ (1 - T)$; (7) $l = l_o + D$, and (8) $P_o = T \times$ required P.

EXAMPLE 1

Select a tension spring for slow reciprocating motion, with 1¼ inches stroke, 15 pounds load at the minimum working length and a load increase factor of 1.667. According to directions B, the load at the max. W.L. $= 15 \times 1.667 = 25$ lb., while the theoretical deflection is found from Table C, equalling 3⅛ in. Using music wire, the stress group, according to Table A, is high. From Table B, a spring of ½ in. O.D., .080 in. wire dia., 26.7 lb. load and 2.39 ratio is selected. As shown on Table D, the initial tension factor should not exceed 0.21, so we may use T = 0.18. The free length $= 3\frac{1}{8} \times 2.39 = 7\frac{1}{2}$ in. and the total deflection $= 3\frac{1}{8} \times (1 - 0.18) = 2\frac{9}{16}$ in. This will make the max. W.L. $= 7\frac{1}{2} + 2\frac{9}{16} = 10\frac{1}{16}$ in., while the initial tension $=$ $0.18 \times 26.7 = 4.8$ pounds.

EXAMPLE 2

Select a tension spring of pretempered carbon steel wire, with a scale or rate of 50 lb. per in. deflection and a max. load of 125 lb., without initial tension. According to directions D, the theoretical deflection is equal to $125/50 = 2\frac{1}{2}$ in. The load is to be applied infrequently and gradually and, therefore, according to Table A, the high stress group should be used. From Table B, we select a spring of 1⅝ in. O.D., 0.207 in. wire diameter and a load constant of 192. The free length $= 192/50 = 3.84$ in. or 3 27/32 in. Since the spring is wound without initial tension, the factor T = O, and the total deflection is equal to the theoretical deflection $= 2\frac{1}{2}$ in. This will make the maximum working length 3 27/32 in. + 2½ in. = 6 11/32 in. Free length and maximum W.L. may be rounded off to 3⅞ in. and 6⅜ in. respectively, without appreciable change of the load scale.

Tension Springs—Table B

Spring O.D. in.	Wire Dia. in.	Load Constant C	Low Stress Group			Medium Stress Group			High Stress Group		
			Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.
	0.014	0.148	0.267	0.554	0.0253	0.334	0.443	0.0316	0.401	0.369	0.0379
	0.0162	0.319	0.412	0.775	0.0209	0.515	0.620	0.0261	0.618	0.517	0.0314
	0.0181	0.574	0.571	1.01	0.0180	0.713	0.805	0.0225	0.856	0.671	0.0270
	0.0204	1.09	0.812	1.34	0.0152	1.02	1.07	0.0190	1.22	0.894	0.0228
3/16	0.023	2.07	1.15	1.80	0.0128	1.44	1.44	0.0160	1.73	1.20	0.0192
	0.0258	3.89	1.61	2.41	0.0107	2.02	1.93	0.0134	2.42	1.61	0.0161
	0.0286	6.85	2.18	3.15	0.0091	2.72	2.52	0.0113	3.26	2.10	0.0136
	0.03175	12.3	2.94	4.17	0.0076	3.68	3.34	0.0095	4.41	2.78	0.0114
	0.0348	20.6	3.82	5.39	0.0065	4.78	4.31	0.0081	5.73	3.60	0.0097
	0.0162	0.125	0.312	0.402	0.0403	0.390	0.322	0.0503	0.468	0.268	0.0604
	0.0181	0.224	0.434	0.517	0.0350	0.542	0.413	0.438	0.650	0.344	0.0526
	0.0204	0.420	0.618	0.678	0.0301	0.773	0.543	0.376	0.927	0.453	0.0450
	0.023	0.791	0.881	0.898	0.0256	1.10	0.719	0.320	1.32	0.599	0.0384
1/4	0.0258	1.46	1.24	1.18	0.0219	1.54	0.945	0.273	1.85	0.787	0.0328
	0.0286	2.53	1.67	1.51	0.0189	2.09	1.21	0.236	2.51	1.01	0.0283
	0.03175	4.46	2.27	1.96	0.0162	2.84	1.57	0.202	3.41	1.31	0.0242
	0.348	7.39	2.97	2.49	0.0140	3.71	1.99	0.175	4.45	1.66	0.0210
	0.041	18.2	4.77	3.83	0.0107	5.96	3.06	0.134	7.15	2.55	0.0161
	0.0204	0.204	0.498	0.409	0.0499	0.623	0.327	0.0624	0.748	0.273	0.0748
	0.023	0.382	0.711	0.536	0.0429	0.890	0.429	0.0536	1.07	0.357	0.0644
	0.0258	0.697	1.00	0.697	0.0370	1.25	0.558	0.0468	1.50	0.465	0.0555
	0.0286	1.20	1.36	0.888	0.0322	1.69	0.710	0.0403	2.03	0.591	0.0484
5/16	0.03175	2.10	1.84	1.14	0.0279	2.31	0.909	0.0349	2.77	0.758	0.0419
	0.0348	3.44	2.42	1.42	0.0245	3.02	1.14	0.0307	3.62	0.946	0.0368
	0.041	8.33	3.90	2.14	0.0192	4.88	1.71	0.0240	5.85	1.42	0.0288
	0.0475	18.7	5.98	3.13	0.0152	7.48	2.50	0.0190	8.98	2.08	0.0228
	0.054	38.3	8.66	4.43	0.0122	10.8	3.53	0.0153	13.0	2.95	0.0183
	0.023	0.212	0.597	0.356	0.0647	0.746	0.284	0.0809	0.895	0.237	0.0970
	0.0258	0.386	0.839	0.460	0.0561	1.05	0.368	0.0701	1.26	0.307	0.0842
	0.0286	0.662	1.14	0.581	0.0492	1.42	0.465	0.0615	1.71	0.387	0.0738
	0.03175	1.15	1.55	0.739	0.0430	1.94	0.591	0.0537	2.33	0.493	0.0644
3/8	0.0348	1.86	2.04	0.914	0.0381	2.55	0.731	0.0476	3.06	0.588	0.0592
	0.041	4.47	3.30	1.36	0.0302	4.12	1.09	0.0378	4.94	0.904	0.0453
	0.0475	9.89	5.07	1.95	0.0243	6.34	1.56	0.0304	7.61	1.30	0.0365
	0.054	19.9	7.36	2.71	0.0199	9.21	2.17	0.0249	11.0	1.81	0.0299
	0.625	44.8	11.2	4.00	0.0156	14.0	3.20	0.0195	16.8	2.67	0.0234
	0.072	99.9	16.8	5.95	0.0121	21.0	4.76	0.0151	25.2	3.96	0.0182
	0.0286	0.402	0.982	0.410	0.0698	1.23	0.328	0.0872	1.47	0.273	0.105
	0.03175	0.695	1.34	0.519	0.0611	1.67	0.415	0.0764	2.01	0.346	0.0917
	0.0348	1.12	1.76	0.640	0.0544	2.19	0.512	0.0680	2.63	0.427	0.0815
	0.41	2.67	2.85	0.938	0.0437	3.56	0.750	0.0547	4.27	0.625	0.0656
	0.0475	5.86	4.39	1.33	0.0356	5.49	1.07	0.0445	6.59	0.889	0.0534
7/16	0.054	11.7	6.40	1.83	0.0295	8.00	1.46	0.0369	9.59	1.22	0.0443
	0.0625	26.0	9.79	2.66	0.0235	12.2	2.12	0.0294	14.7	1.77	0.0353
	0.072	56.9	14.8	3.86	0.0186	18.4	3.09	0.0233	22.1	2.57	0.0280
	0.080	103	19.9	5.17	0.0155	24.9	4.14	0.0193	29.9	3.45	0.0232
	0.03175	0.452	1.18	0.385	0.0826	1.47	0.308	0.103	1.76	0.256	0.124
	0.0348	0.728	1.54	0.472	0.0737	1.93	0.378	0.0921	2.31	0.315	0.111
	0.041	1.72	2.51	0.687	0.0597	3.13	0.550	0.0746	3.76	0.458	0.0895
	0.0475	3.75	3.87	0.969	0.0490	4.84	0.775	0.0613	5.81	0.646	0.0736
	0.054	7.42	5.65	1.31	0.0411	7.06	1.05	0.0513	8.48	0.877	0.0615
1/2	0.0625	16.4	8.67	1.89	0.0331	10.8	1.51	0.0414	13.0	1.26	0.0497
	0.072	35.5	13.1	2.71	0.0266	16.4	2.17	0.0332	19.6	1.81	0.0399
	0.080	63.7	17.8	3.58	0.0224	22.2	2.86	0.0279	26.7	2.39	0.0335
	0.0915	135	26.1	5.18	0.0177	32.6	4.14	0.0221	39.2	3.45	0.0265
	3/32	155	28.0	5.55	0.0169	35.0	4.44	0.0211	42.0	3.70	0.0253
	0.348	0.499	1.38	0.363	0.0959	1.72	0.290	0.120	2.06	0.242	0.144
	0.041	1.17	2.24	0.524	0.0782	2.80	0.419	0.0978	3.36	0.349	0.117
	0.0475	2.54	3.46	0.735	0.0646	4.33	0.588	0.0808	5.19	0.490	0.0970
	0.054	5.02	5.06	0.992	0.0544	6.32	0.794	0.0680	7.59	0.662	0.0816
9/16	0.0625	11.0	7.77	1.41	0.0443	9.72	1.13	0.0554	11.7	0.941	0.0665
	0.072	23.6	11.8	2.00	0.0359	14.7	1.60	0.0449	17.6	1.34	0.0539
	0.080	42.0	16.0	2.62	0.0305	20.0	2.10	0.0381	24.0	1.75	0.0458
	0.0915	88.3	23.6	3.74	0.0244	29.5	3.00	0.0305	35.3	2.50	0.0367
	3/32	101	25.3	4.00	0.0234	31.6	3.20	0.0293	37.9	2.67	0.0352

Tension Springs—Table B (continued)

Spring O.D. in.	Wire Dia. in.	Load Constant C	Low Stress Group			Medium Stress Group			High Stress Group		
			Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.
	0.041	0.836	2.02	0.413	0.0992	2.53	0.331	0.124	3.03	0.276	0.149
	0.0475	1.80	3.13	0.576	0.0824	3.90	0.461	0.103	4.68	0.384	0.124
	0.054	3.55	4.58	0.775	0.0697	5.72	0.620	0.0871	6.86	0.516	0.105
	0.0625	7.70	7.04	1.09	0.0572	8.80	0.875	0.0714	10.6	0.729	0.0858
	0.072	16.4	10.7	1.54	0.0467	13.3	1.23	0.0584	16.0	1.03	0.0701
5/8	0.080	29.1	14.5	2.00	0.0399	18.2	1.60	0.0499	21.8	1.34	0.0599
	0.0915	60.7	21.5	2.83	0.0324	26.8	2.26	0.0405	32.2	1.89	0.0485
	3/32	69.4	23.0	3.02	0.0311	28.8	2.41	0.0389	34.5	2.01	0.0466
	0.1055	134	29.7	4.51	0.0234	36.4	3.68	0.0287	43.7	3.07	0.0344
	0.1205	284	43.3	6.56	0.0184	53.2	5.35	0.0225	63.8	4.45	0.0271
	1/8	351	48.1	7.30	0.0171	59.0	5.95	0.0210	70.8	4.96	0.0252
	0.041	0.616	1.84	0.334	0.123	2.30	0.267	0.153	2.77	0.223	0.184
	0.0475	1.33	2.85	0.465	0.102	3.57	0.372	0.128	4.28	0.310	0.153
	0.054	2.60	4.18	0.622	0.0869	5.22	0.497	0.109	6.26	0.414	0.130
	0.0625	5.61	6.43	0.873	0.0716	8.04	0.699	0.0894	9.64	0.582	0.107
	0.072	11.9	9.76	1.22	0.0590	12.2	0.978	0.0737	14.6	0.815	0.0884
	0.080	21.0	13.3	1.58	0.0506	16.6	1.26	0.0633	19.9	1.05	0.0759
11/16	0.0915	43.5	19.7	2.21	0.0414	24.6	1.77	0.0517	29.5	1.47	0.0621
	3/32	49.7	21.1	2.35	0.0398	26.4	1.88	0.0498	31.7	1.57	0.0597
	0.1055	95.4	27.3	3.49	0.0302	33.5	2.85	0.0371	40.2	2.37	0.0445
	0.1205	200	40.0	5.01	0.0241	49.1	4.08	0.0295	58.9	3.40	0.0354
	1/8	246	44.4	5.55	0.0225	54.5	4.52	0.0276	65.4	3.77	0.0332
	0.135	382	55.2	6.92	0.0195	67.8	5.64	0.0239	81.4	4.70	0.0287
	0.0475	1.00	2.62	0.382	0.124	3.28	0.306	0.155	3.94	0.255	0.187
	0.054	1.96	3.84	0.510	0.106	4.80	0.408	0.132	5.76	0.340	0.159
	0.0625	4.22	5.92	0.713	0.0877	7.40	0.570	0.110	8.88	0.475	0.132
	0.072	8.92	8.99	0.992	0.0726	11.2	0.794	0.0907	13.5	0.662	0.109
	0.080	15.7	12.3	1.28	0.0626	15.3	1.02	0.0782	18.4	0.852	0.0939
	0.0915	32.3	18.2	1.78	0.0515	22.7	1.42	0.0644	27.3	1.19	0.0772
3/4	3/32	36.8	19.5	1.89	0.0497	24.4	1.51	0.0621	29.3	1.26	0.0745
	0.1055	70.2	25.2	2.78	0.0379	31.0	2.27	0.0466	37.2	1.89	0.0558
	0.1205	147	37.1	3.95	0.0305	45.5	3.22	0.0374	54.6	2.69	0.0449
	1/8	180	41.2	4.37	0.0286	50.5	3.56	0.0351	60.6	2.97	0.0422
	0.135	277	51.4	5.39	0.250	63.0	4.40	0.0307	75.6	3.66	0.0369
	0.1483	473	67.0	7.05	0.0210	82.3	5.76	0.0258	98.7	4.79	0.0310
	0.054	1.19	3.31	0.361	0.150	4.13	0.289	0.187	4.96	0.240	0.225
	0.0625	2.55	5.10	0.501	0.125	6.38	0.401	0.156	7.65	0.334	0.187
	0.072	5.36	7.76	0.692	0.104	9.70	0.554	0.130	11.6	0.462	0.156
	0.080	9.38	10.6	0.885	0.0904	13.2	0.708	0.113	15.9	0.590	0.136
	0.0915	19.2	15.7	1.22	0.0751	19.7	0.974	0.0939	23.6	0.812	0.113
	3/32	21.8	16.9	1.29	0.0726	21.1	1.03	0.0907	25.3	0.861	0.109
	0.1055	41.3	21.9	1.88	0.0561	26.9	1.53	0.0688	32.3	1.28	0.0826
7/8	0.1205	85.0	32.3	2.63	0.0458	39.6	2.15	0.0562	47.6	1.79	0.0674
	1/8	104	35.9	2.90	0.0432	44.1	2.36	0.0530	52.9	1.97	0.0636
	0.135	159	44.9	3.54	0.0381	55.1	2.89	0.0468	66.2	2.40	0.0561
	0.1483	268	58.8	4.57	0.0325	72.2	3.72	0.0399	86.6	3.10	0.0478
	5/32	362	68.5	5.28	0.0296	84.0	4.30	0.0363	101	3.58	0.0436
	0.162	443	75.7	5.85	0.0277	92.9	4.77	0.0339	112	3.98	0.0407
	0.177	733	97.3	7.55	0.0235	119	6.15	0.0288	143	5.12	0.0345
	0.0625	1.66	4.48	0.371	0.168	5.60	0.297	0.211	6.72	0.247	0.253
	0.072	3.48	6.82	0.510	0.141	8.53	0.408	0.177	10.2	0.340	0.212
	0.080	6.07	9.33	0.650	0.123	11.7	0.520	0.154	14.0	0.433	0.185
	0.0915	12.3	13.9	0.887	0.103	17.3	0.709	0.129	20.8	0.591	0.155
	3/32	14.0	14.9	0.939	0.0998	18.6	0.752	0.125	22.3	0.626	0.150
	0.1055	26.2	19.3	1.36	0.0777	23.7	1.11	0.0954	28.5	0.921	0.115
	0.1205	53.7	28.6	1.88	0.0641	35.1	1.53	0.0787	42.1	1.28	0.0945
1	1/8	65.5	31.8	2.06	0.0607	39.0	1.68	0.0745	46.8	1.40	0.0894
	0.135	99.5	39.8	2.50	0.0539	48.8	2.04	0.0662	58.6	1.70	0.0794
	0.1483	167	52.3	3.19	0.0465	64.2	2.60	0.0570	77.0	2.17	0.0685
	5/32	223	60.9	3.67	0.0426	74.7	2.99	0.0523	89.6	2.49	0.0628
	0.162	272	67.5	4.04	0.0401	82.8	3.29	0.0492	99.4	2.74	0.0591
	0.177	448	87.0	5.15	0.0344	107	4.19	0.0422	128	3.49	0.0507
	3/16	622	103	6.06	0.0310	126	4.94	0.0380	151	4.11	0.0456
	0.192	713	110	6.48	0.0296	135	5.28	0.0364	162	4.40	0.0436

Tension Springs—Table B (continued)

Spring O.D. in.	Wire Dia. in.	Load Constant C	Low Stress Group			Medium Stress Group			High Stress Group		
			Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.	Safe Load P lb.	Spring Ratio R	Defl. Per Coil f in.
	0.072	2.38	6.09	0.391	0.184	7.61	0.313	0.230	9.14	0.261	0.276
	0.080	4.13	8.33	0.496	0.161	10.4	0.396	0.202	12.5	0.330	0.242
	0.0915	8.35	12.4	0.674	0.136	15.5	0.539	0.170	18.6	0.449	0.204
	3/32	9.48	13.3	0.713	0.132	16.6	0.570	0.164	20.0	0.475	0.197
	0.1055	17.7	17.3	1.03	0.103	21.2	0.836	0.126	25.5	0.696	0.152
	0.1205	36.1	25.6	1.41	0.0856	31.4	1.15	0.105	37.7	0.956	0.126
	1/8	43.9	28.5	1.54	0.0812	35.0	1.25	0.0997	42.0	1.05	0.120
	0.135	66.3	35.7	1.86	0.0726	43.8	1.51	0.0891	52.6	1.26	0.107
1 1/8	0.1483	111	47.0	2.35	0.0630	57.7	1.92	0.0773	69.3	1.60	0.0928
	5/32	147	54.8	2.69	0.0581	67.2	2.19	0.0713	80.7	1.83	0.0855
	0.162	180	60.7	2.96	0.0548	74.5	2.41	0.0672	89.4	2.01	0.0807
	0.177	293	78.5	3.73	0.0474	96.4	3.04	0.0582	116	2.53	0.0698
	3/16	404	92.6	4.36	0.0430	114	3.56	0.0527	136	2.96	0.0633
	0.192	462	99.2	4.65	0.0413	122	3.79	0.0506	146	3.16	0.0608
	0.207	706	123	5.74	0.0361	151	4.68	0.0443	181	3.90	0.0531
	0.2253	1146	156	7.33	0.0307	192	5.97	0.0377	230	4.98	0.0453
	0.080	2.95	7.52	0.391	0.205	9.42	0.313	0.256	11.3	0.261	0.307
	0.0915	5.93	11.2	0.530	0.173	14.0	0.424	0.216	16.8	0.353	0.259
	3/32	6.74	12.0	0.560	0.168	15.0	0.448	0.209	18.1	0.373	0.251
	0.1055	12.5	15.6	0.801	0.132	19.2	0.653	0.162	23.0	0.544	0.194
	0.1205	25.3	23.2	1.09	0.110	28.4	0.892	0.135	34.1	0.743	0.162
	1/8	30.8	25.8	1.20	0.105	31.6	0.975	0.128	37.9	0.812	0.154
	0.135	46.5	32.4	1.44	0.0941	39.8	1.17	0.115	47.7	0.975	0.139
	0.1483	77.1	42.6	1.81	0.0820	52.3	1.47	0.101	62.8	1.23	0.121
1 1/4	5/32	102	49.7	2.06	0.0759	61.0	1.68	0.0931	73.2	1.40	0.112
	0.162	125	55.2	2.26	0.0718	67.8	1.84	0.0882	81.3	1.53	0.106
	0.177	202	71.5	2.83	0.0626	87.8	2.30	0.0768	105	1.92	0.0922
	3/16	278	84.4	3.29	0.0570	104	2.68	0.0699	124	2.23	0.0839
	0.192	317	90.5	3.50	0.0548	111	2.85	0.0673	133	2.38	0.0807
	0.207	481	112	4.29	0.0483	138	3.49	0.0593	165	2.91	0.0711
	0.2253	775	143	5.43	0.0415	175	4.42	0.0510	210	3.68	0.0612
	0.2437	1212	163	7.46	0.0327	195	6.21	0.0392	234	5.18	0.0471
	1/4	1404	175	8.03	0.0311	210	6.69	0.0374	252	5.58	0.0448
	0.0915	4.36	10.2	0.427	0.214	12.8	0.342	0.268	15.3	0.285	0.321
	3/32	4.95	11.0	0.451	0.208	13.7	0.361	0.260	16.5	0.301	0.312
	0.1055	9.18	14.3	0.643	0.164	17.5	0.524	0.201	21.0	0.437	0.242
	0.1205	18.5	21.2	0.875	0.138	26.0	0.713	0.169	31.2	0.594	0.203
	1/8	22.5	23.6	0.953	0.131	28.9	0.776	0.161	34.7	0.647	0.193
	0.135	33.8	29.6	1.14	0.118	36.3	0.931	0.145	43.6	0.776	0.174
	0.1483	55.9	39.0	1.43	0.104	47.9	1.17	0.127	57.5	0.972	0.153
	5/32	74.0	45.5	1.63	0.0961	55.8	1.33	0.118	67.0	1.10	0.142
1 3/8	0.162	89.9	50.6	1.78	0.0911	62.0	1.45	0.112	74.4	1.21	0.134
	0.177	145	65.5	2.22	0.0798	80.4	1.81	0.0980	96.5	1.51	0.118
	3/16	199	77.5	2.57	0.0730	95.1	2.09	0.0896	114	1.74	0.108
	0.192	227	83.0	2.73	0.0704	102	2.22	0.0864	122	1.85	0.104
	0.207	343	103	3.32	0.0623	127	2.71	0.0765	152	2.26	0.0918
	0.2253	549	132	4.17	0.0541	162	3.40	0.0664	194	2.83	0.0797
	0.2437	854	150	5.69	0.0429	180	4.74	0.0514	216	3.95	0.0617
	1/4	986	162	6.11	0.0409	194	5.09	0.0491	233	4.24	0.0590
	0.2625	1301	185	7.01	0.0374	223	5.85	0.0449	267	4.87	0.0539
	3/32	3.75	10.1	0.371	0.253	12.6	0.297	0.316	15.1	0.247	0.379
	0.1055	6.93	13.1	0.528	0.200	16.1	0.430	0.245	19.3	0.358	0.295
	0.1205	13.9	19.5	0.715	0.169	23.9	0.582	0.207	28.7	0.485	0.248
	1/8	16.9	21.7	0.777	0.161	26.6	0.634	0.197	32.0	0.528	0.237
	0.135	25.3	27.2	0.930	0.145	33.4	0.758	0.178	40.1	0.631	0.214
	0.1483	41.7	36.0	1.16	0.128	44.1	0.946	0.157	52.9	0.788	0.188
	5/32	55.2	41.9	1.32	0.119	51.4	1.07	0.146	61.7	0.894	0.175
	0.162	67.0	46.6	1.44	0.113	57.2	1.17	0.138	68.7	0.975	0.166
	0.177	108	60.4	1.78	0.0992	74.2	1.45	0.122	89.0	1.21	0.146
1 1/2	3/16	147	71.6	2.06	0.0910	87.8	1.68	0.112	105	1.40	0.134
	0.192	168	76.7	2.19	0.0878	94.1	1.78	0.108	113	1.48	0.129
	0.207	253	95.5	2.65	0.0782	117	2.16	0.0960	141	1.80	0.115
	0.2253	403	122	3.30	0.0683	150	2.69	0.0838	180	2.24	0.101
	0.2437	623	139	4.48	0.0545	167	3.73	0.0653	200	3.11	0.0784
	1/4	719	150	4.80	0.0521	180	4.00	0.0625	216	3.33	0.0750
	0.2625	945	172	5.49	0.0479	207	4.57	0.0574	248	3.81	0.0689
	0.283	1448	214	6.78	0.0417	256	5.65	0.0501	307	4.71	0.0601
	0.3065	2287	267	8.55	0.0358	321	7.13	0.0430	385	5.94	0.0516

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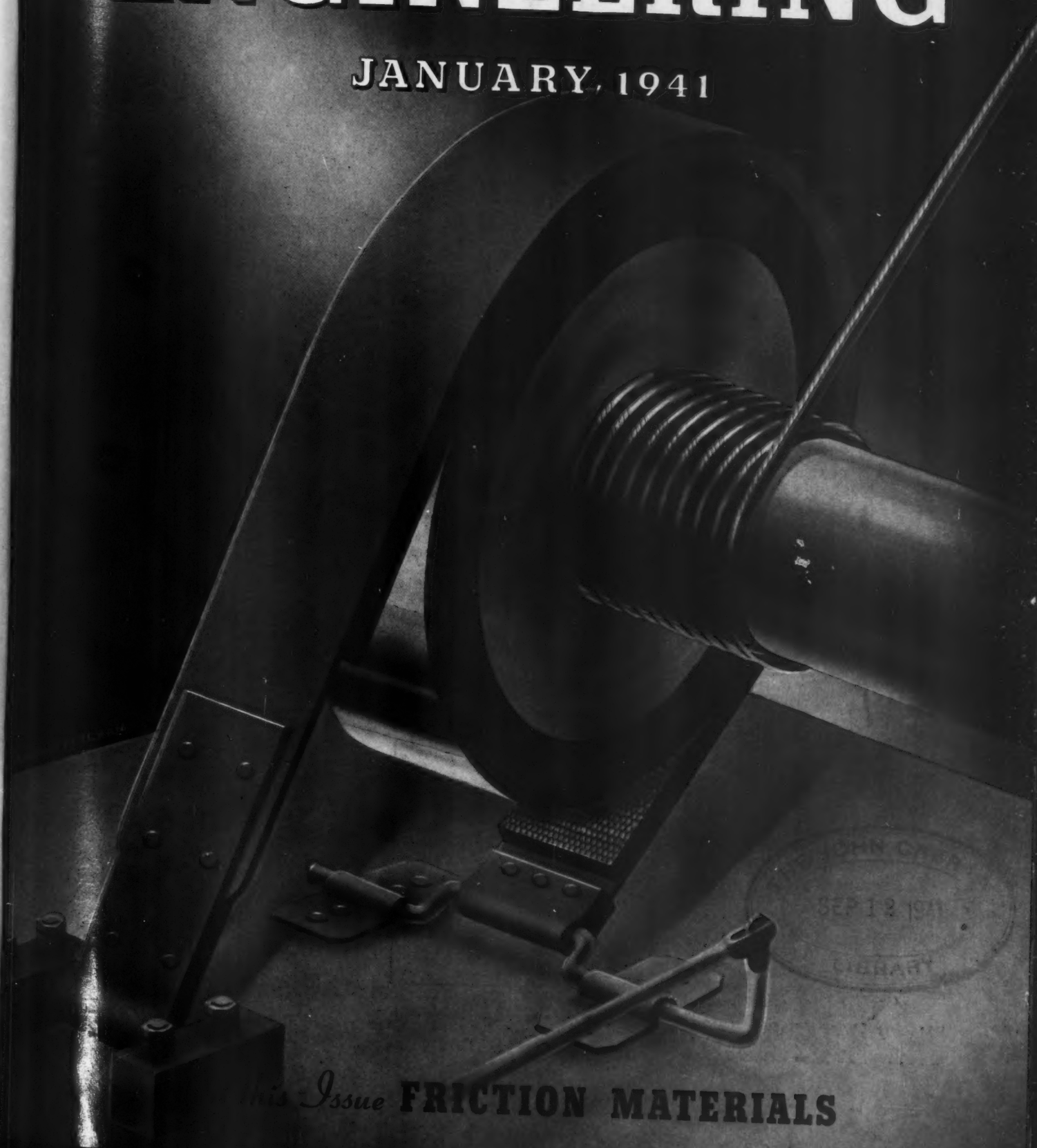

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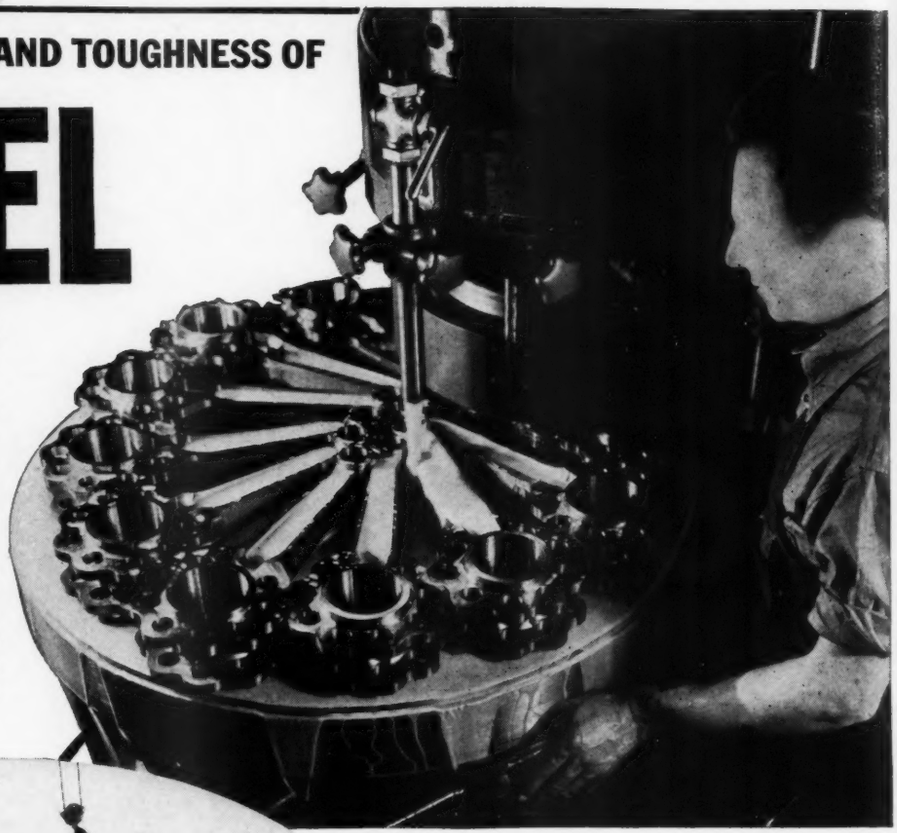
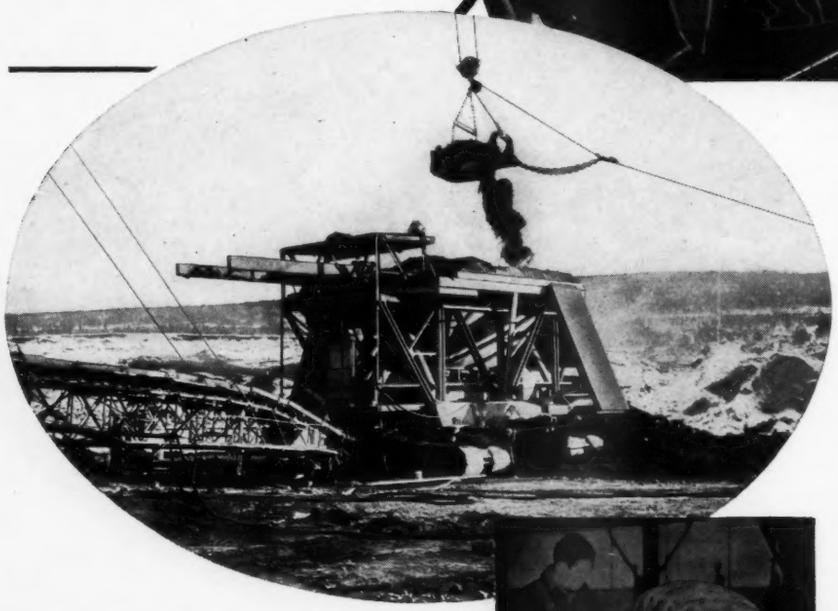


NEW JERSEY—Compactness, light weight, high strength and fatigue resistance are life-and-death requirements for aircraft engine parts. Here you see connecting rods of Nickel-chromium-molybdenum steel machined at the Paterson, New Jersey, plant of WRIGHT AERONAUTICAL CORP. Through their uniform response to heat treatment and ready machinability at high hardness, Nickel alloy steels simplify production.



ALASKA—Stripping 60 million cubic yards of frozen soil from 16 million cubic yards of gold bearing gravel is the job of this Bucyrus-Monighan electric drag line and BUCYRUS-ERIE traveling feeder. Working near Fairbanks, Alaska—more than 2,000 miles away from replacement parts—embrittlement and breakage at subzero temperatures must be avoided. More than 17 tons of 3½% Nickel low carbon steel forgings were used, chiefly for shafting. Three tons of 1.50/2.00% Nickel steel castings are also employed. Gears, pinions and crawler parts are heat-treated Nickel-chromium steel. The mile long conveyor belt system, furnished by the PACIFIC CAR & FOUNDRY CO., depends on speed reducer shafts of tough Nickel-chromium-molybdenum steel, SAE 4340.

NEW YORK—Cost records show this power-driven INGERSOLL-RAND Impact Wrench 6 to 8 times faster and more efficient than hand methods for applying and removing nuts. The hammers and anvils which withstand up to 1100 torsional impacts per minute are Nickel-chromium-molybdenum steel. Nickel alloy steel is readily hardened to prevent battering and stoutly resists wear and fatigue.

• • •

AVOID BREAKDOWNS and costly delays by specifying new equipment and replacement parts in tough, shock-resisting Nickel alloy steels. For practical information about recommended applications of Nickel alloyed materials, please address:

THE INTERNATIONAL NICKEL COMPANY, INC. **67 WALL STREET NEW YORK, N. Y.**

PRODUCT ENGINEERING

FEBRUARY, 1941

In this Issue **CONTROL CIRCUITS**

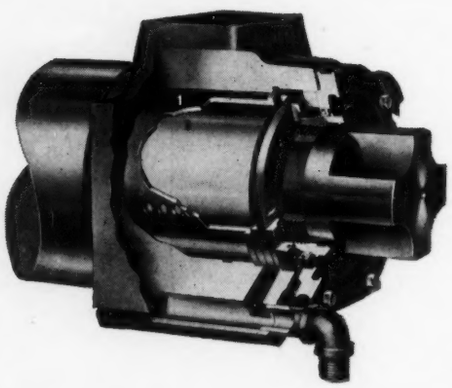
5,000,000 POUND LOADS...

...yet *these* bearings *stand up!*

NICKEL

ALLOY STEELS

Bearings must take terrific poundings in high-speed rolling mills. This 44 in. bearing sleeve safely withstands pressures above 5,250,000 lbs. After years of research and experience, the MORGAN CONSTRUCTION CO., has standardized on Nickel-molybdenum steel for roll neck bearing sleeves. Nickel alloy steel retains its finish and maintains alignment.



This convention exhibit shows how Nickel alloy steel MORGOIL bearing sleeves are mounted for high speed operation in a continuous strip mill. Production economies and increased output naturally follow the increased abilities of tougher Nickel alloyed materials.

Diagram showing the ASARCOLOY bushing (marked 1) which backs up the Nickel alloy steel bearing sleeve (marked 2). Asarcoloy is a cadmium Nickel material with a very low coefficient of friction.

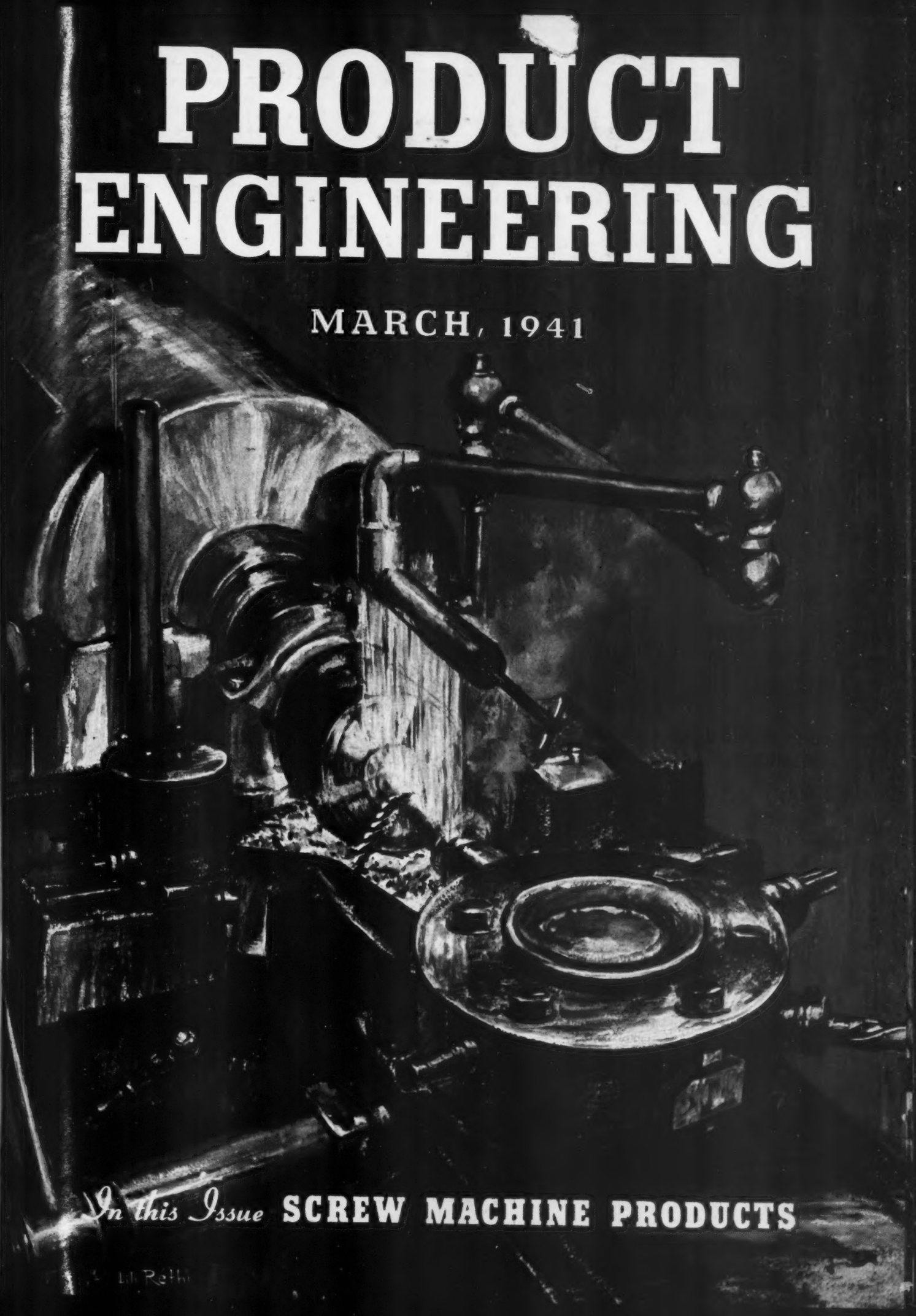
Confronted by tougher production schedules this year, don't get caught with your bearings down. Avoid breakdowns by specifying bearings strengthened and toughened by Nickel alloyed materials. Helpful, practical advice on efficient bearing metals and mountings is available promptly upon your request to:

THE INTERNATIONAL NICKEL COMPANY, INC.

67 WALL STREET
NEW YORK, N. Y.

PRODUCT ENGINEERING

MARCH, 1941



In this Issue **SCREW MACHINE PRODUCTS**

MONEY-SAVING IDEAS

for EQUIPMENT BUILDERS

Nickel Cast Iron News
Published in the Interest of Producers and Users of Cast Iron
Orientals Make Good Use of Alloy Iron Castings
New Abrasion Service Records Made Available
Nickel Steel Topics
Published in the Interest of Producers and Users of Nickel Alloy Steels
Screwdrivers Made to Withstand Rough Treatment
Nickel Steels Play Important Role in Machine Tools
"Bicycle Built for Two" (Speeds)

Two periodicals mailed FREE on request, cite actual cases

NICKEL STEEL TOPICS—This twelve page illustrated, miniature newspaper is published every second month and is devoted exclusively to Nickel alloy steels. Each issue is packed with illustrated technical and news articles dealing with the production, treatment and uses of these steels in rolled, forged and cast forms. Special features such as a question and answer page and pertinent editorials on technical subjects involving the uses of Nickel alloy steels are included in every issue.

NICKEL CAST IRON NEWS—This publication is a 12 page, illustrated newspaper-type periodical devoted to technical and news articles featuring the production of Nickel cast irons. Editorials and a question and answer section on these materials are special features in each issue. "Nickel Cast Iron News" alternates on a monthly basis with "Nickel Steel Topics".

NICKEL STEELS • CAST IRONS

AVAILABLE ON REQUEST—More Than 75 Publications Covering Various Industrial Fields, Applications and Production Procedures.

Permanently valuable for reference purposes are a large group of publications applying to various industrial applications and production procedures involving the uses of Nickel alloy steels, Nickel cast irons or Nickel containing non-ferrous materials. The titles of these publications with a brief description of their respective contents are set forth in a special catalogue, available on request. For your copy, simply return the coupon below.

The factual, informative material appearing in "Nickel Steel Topics" and "Nickel Cast Iron News" is of considerable practical value as evidenced by the fact that over 100,000 engineers, metallurgists and production men are now regularly reading these publications. You may read them too, at no cost or obligation. Simply mail the coupon at right.

I'D LIKE TO KEEP UP WITH THE NEWS

The International Nickel Company, Inc., 67 Wall St., New York, N. Y.

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PRODUCT ENGINEERING

APRIL, 1941

DESIGNS FOR SPEEDIER PRODUCTION

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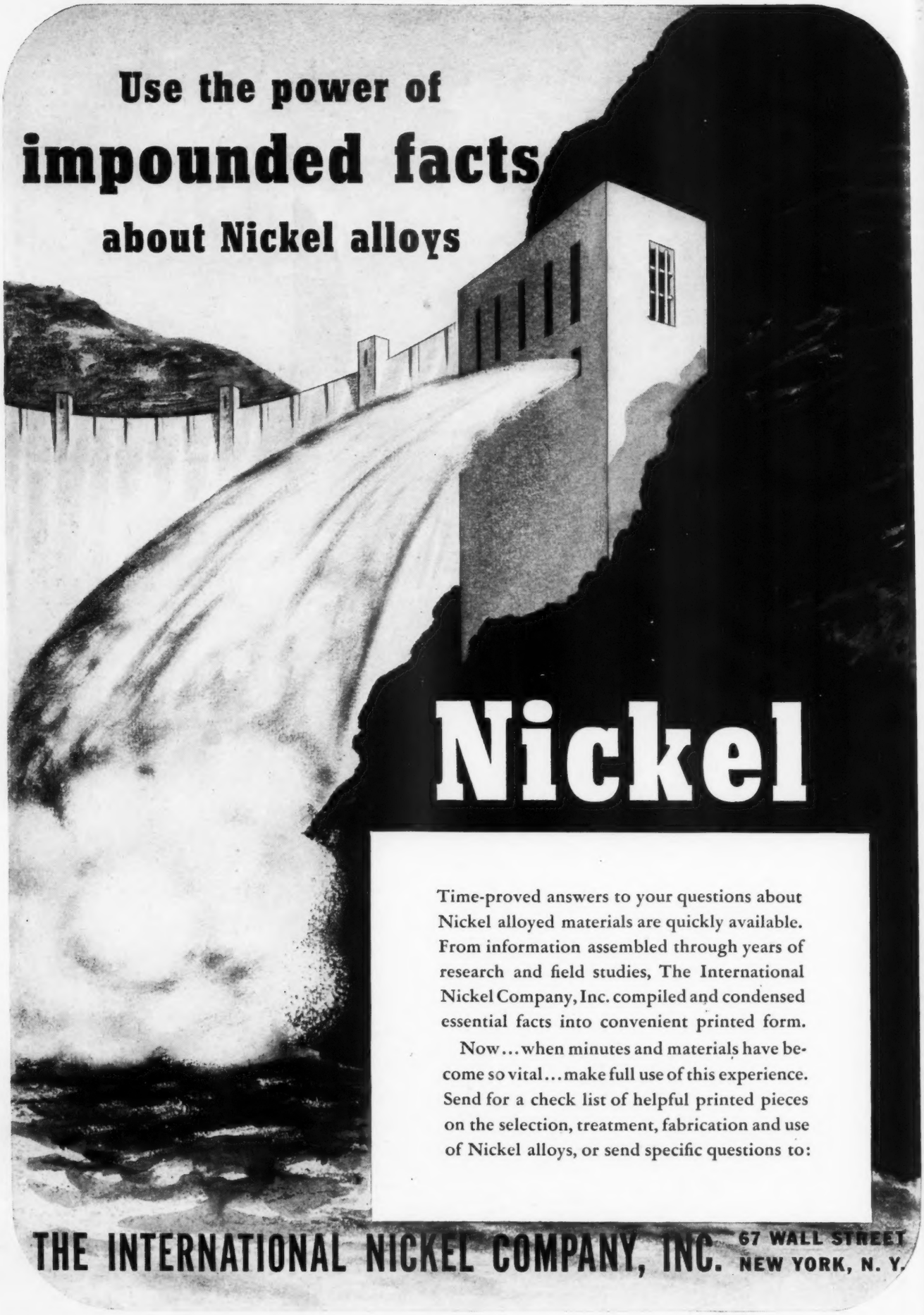

Time-proved answers to your questions about Nickel alloyed materials are quickly available. From information assembled through years of research and field studies, The International Nickel Company, Inc. compiled and condensed essential facts into convenient printed form.

Now... when minutes and materials have become so vital... make full use of this experience. Send for a check list of helpful printed pieces on the selection, treatment, fabrication and use of Nickel alloys, or send specific questions to:

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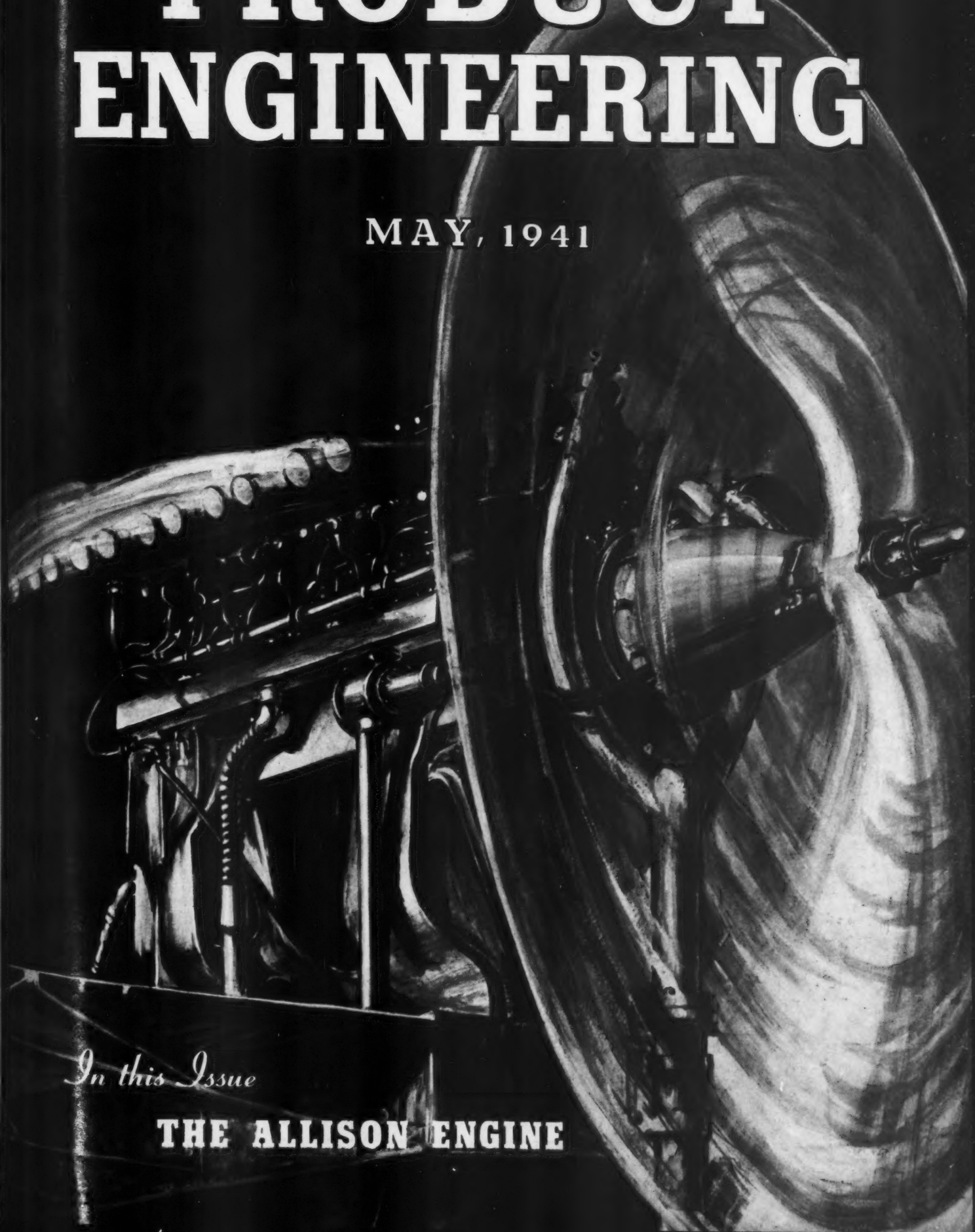
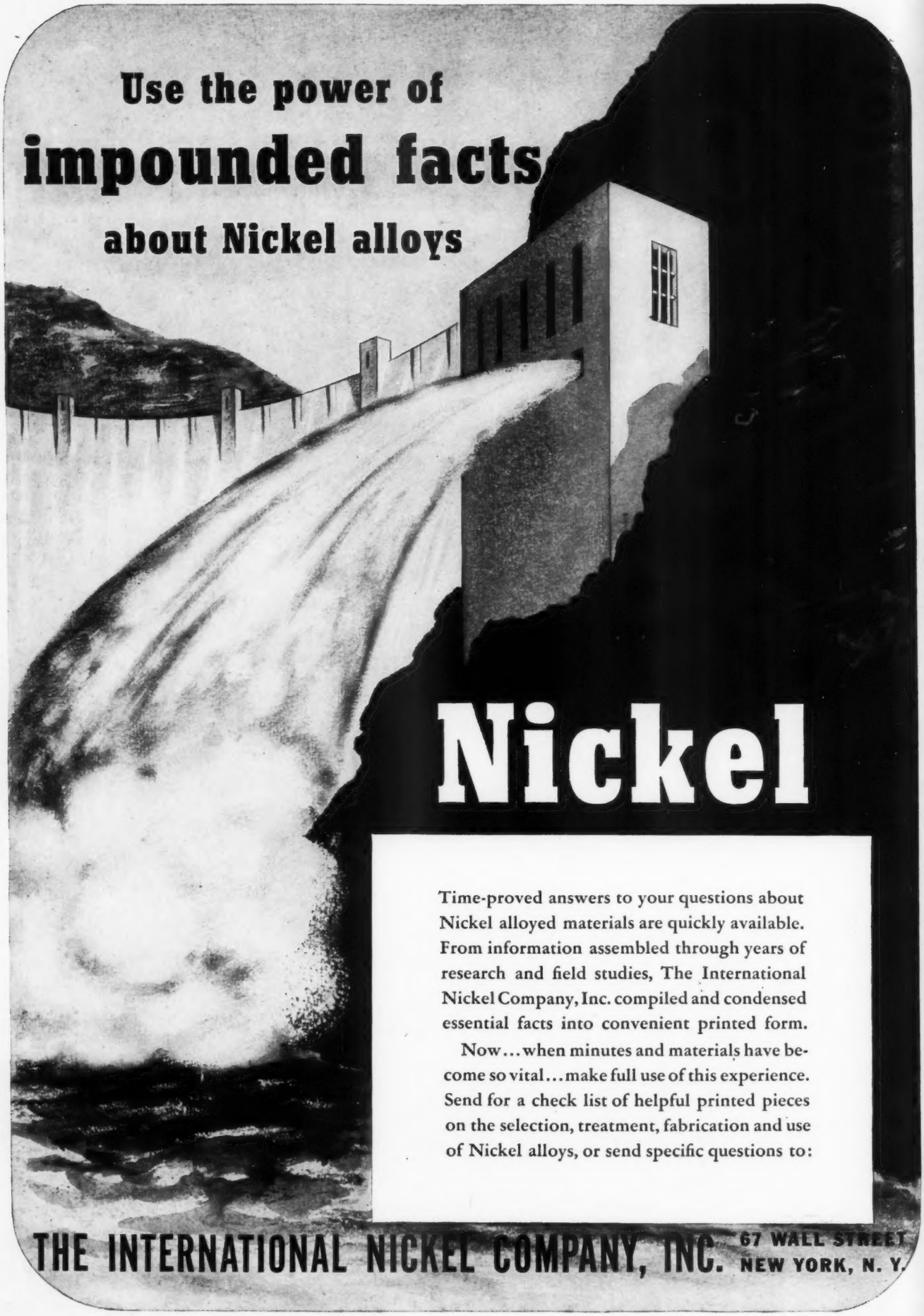


In this Issue

THE ALLISON ENGINE



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PRODUCT ENGINEERING

JUNE, 1941

In this Issue **CAST PHENOLICS**

To assist manufacturers and engineers in finding practical solutions to problems involving the selection, treatment, fabrication and use of alloys containing Nickel, The International Nickel Company, Inc. have compiled essential facts based on years of research and field studies. These facts are condensed into convenient printed form.

Also available for consultation is a staff of experienced engineers—men who have cooperated for years with producers and manufacturers—helping to work out solutions for a wide range of metallurgical problems.

Now—when minutes and materials are so vital to defense efforts—make full use of this service. Send for a check list of helpful publications, or submit your specific problem to:

NICKEL

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67 WALL STREET
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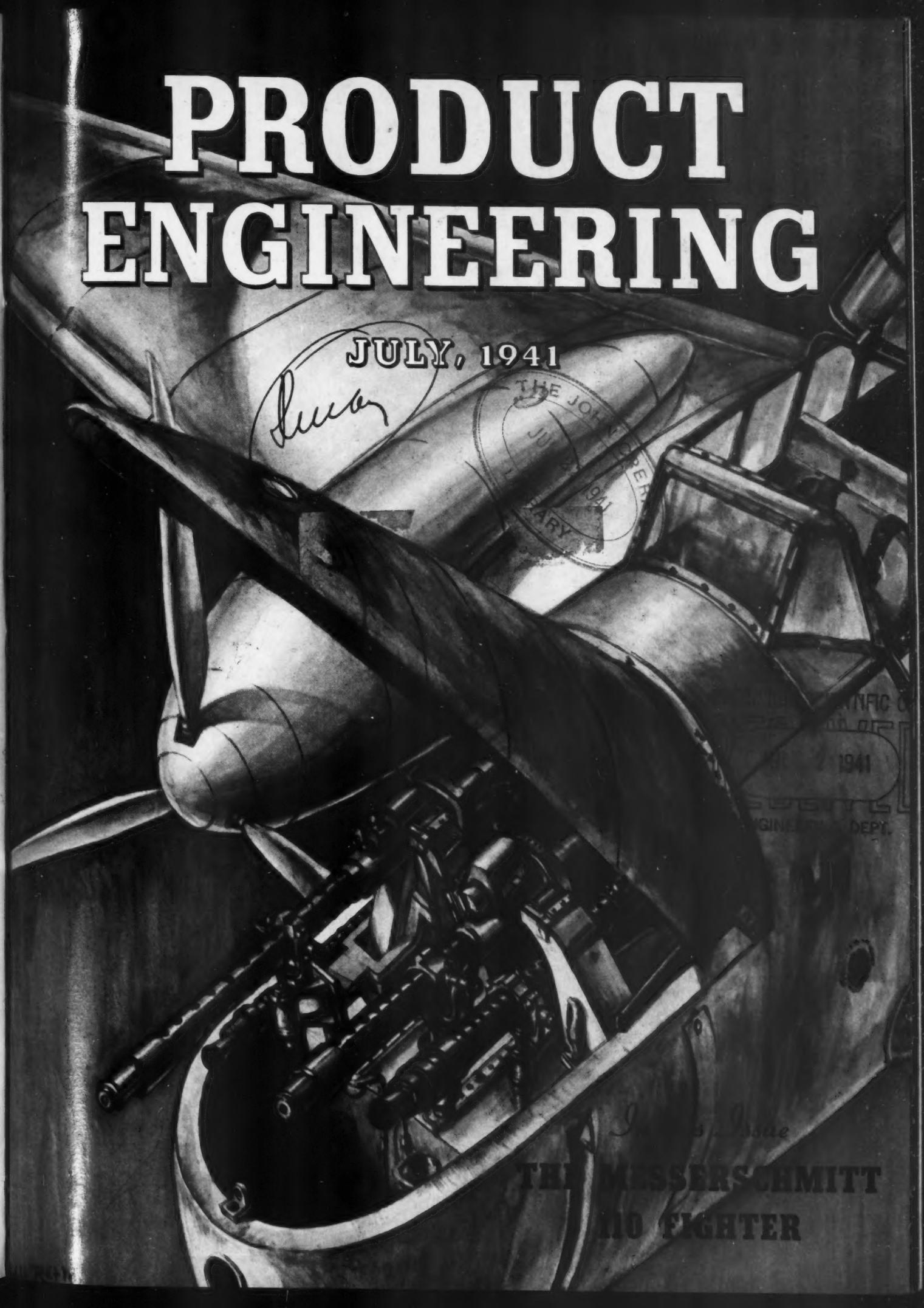
JULY, 1941



DRAW ON THIS STORE OF USER EXPERIENCE TO SPEED DEFENSE

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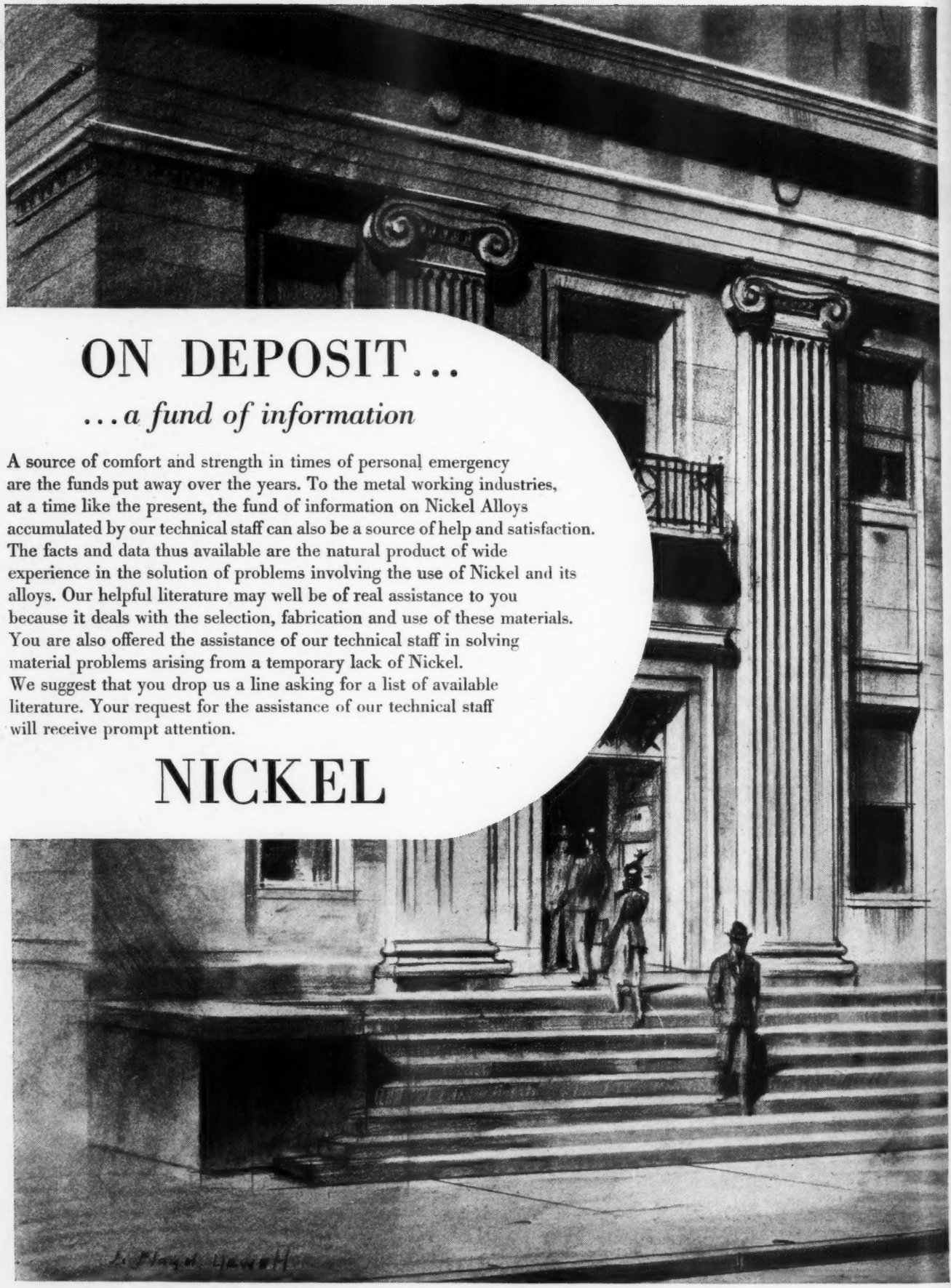
PRODUCT ENGINEERING

AUGUST, 1941

In this Issue **U. S. ARMAMENTS AGAIN SUPERIOR**



ON DEPOSIT...

...a fund of information

A source of comfort and strength in times of personal emergency are the funds put away over the years. To the metal working industries, at a time like the present, the fund of information on Nickel Alloys accumulated by our technical staff can also be a source of help and satisfaction. The facts and data thus available are the natural product of wide experience in the solution of problems involving the use of Nickel and its alloys. Our helpful literature may well be of real assistance to you because it deals with the selection, fabrication and use of these materials. You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. We suggest that you drop us a line asking for a list of available literature. Your request for the assistance of our technical staff will receive prompt attention.

NICKEL

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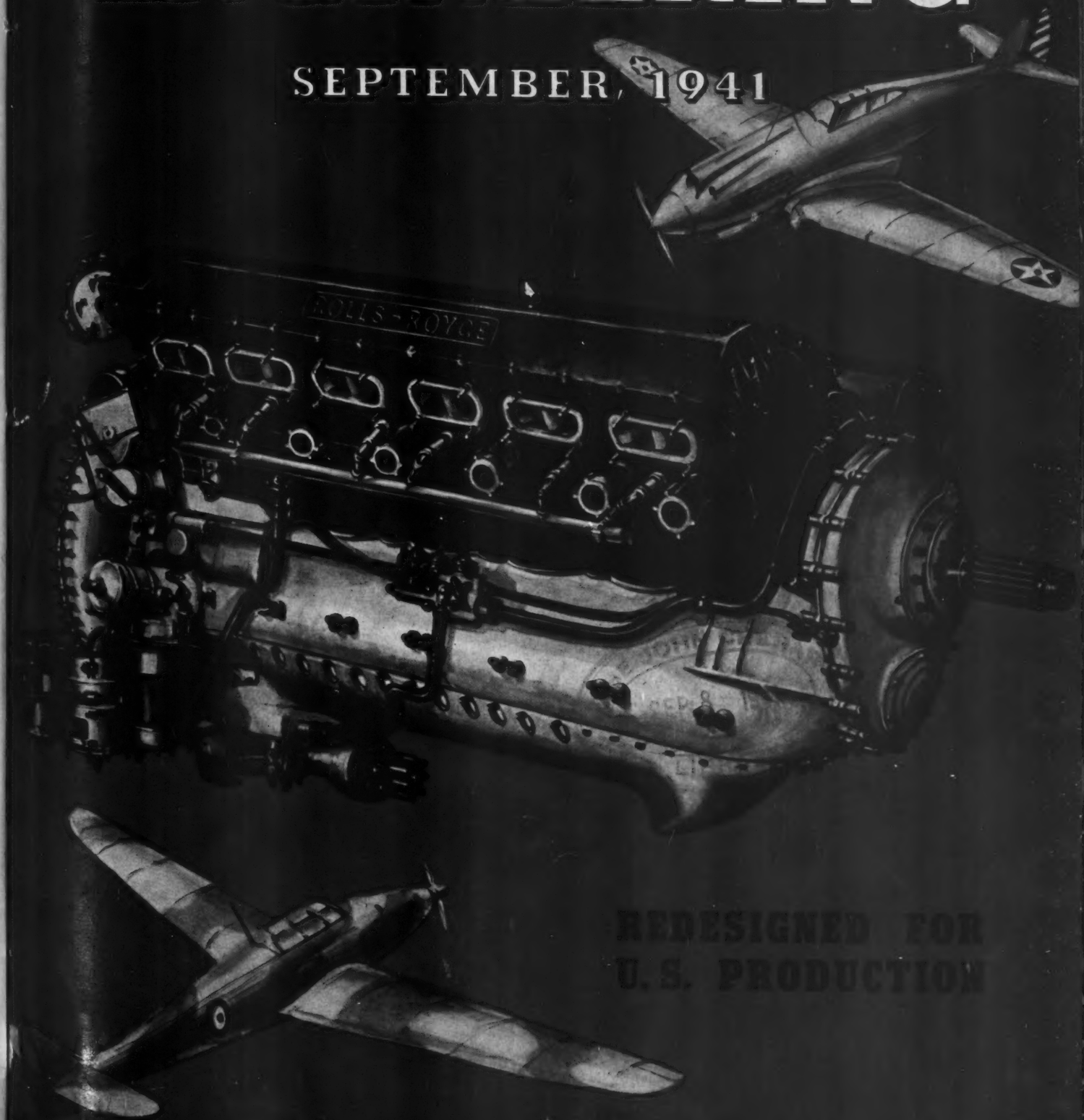
PRODUCT ENGINEERING

SEPTEMBER, 1941



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A
TREASURE CHEST
of useful information...

From time to time over a period of years our technical staff has unearthed new facts concerning metals. This wealth of information has been accumulated out of wide experience in the solution of problems involving the use of Nickel and its alloys.

On the basis of this experience much helpful literature has been compiled. Dealing with the selection, fabrication and use of Nickel alloys it can be of great help to the metal working industries at a time like the present.

In addition to printed matter, we are glad to make available the assistance of our technical staff in solving problems arising from a temporary lack of Nickel. Your request for literature or personal consultation will receive our prompt attention.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

PRODUCT ENGINEERING

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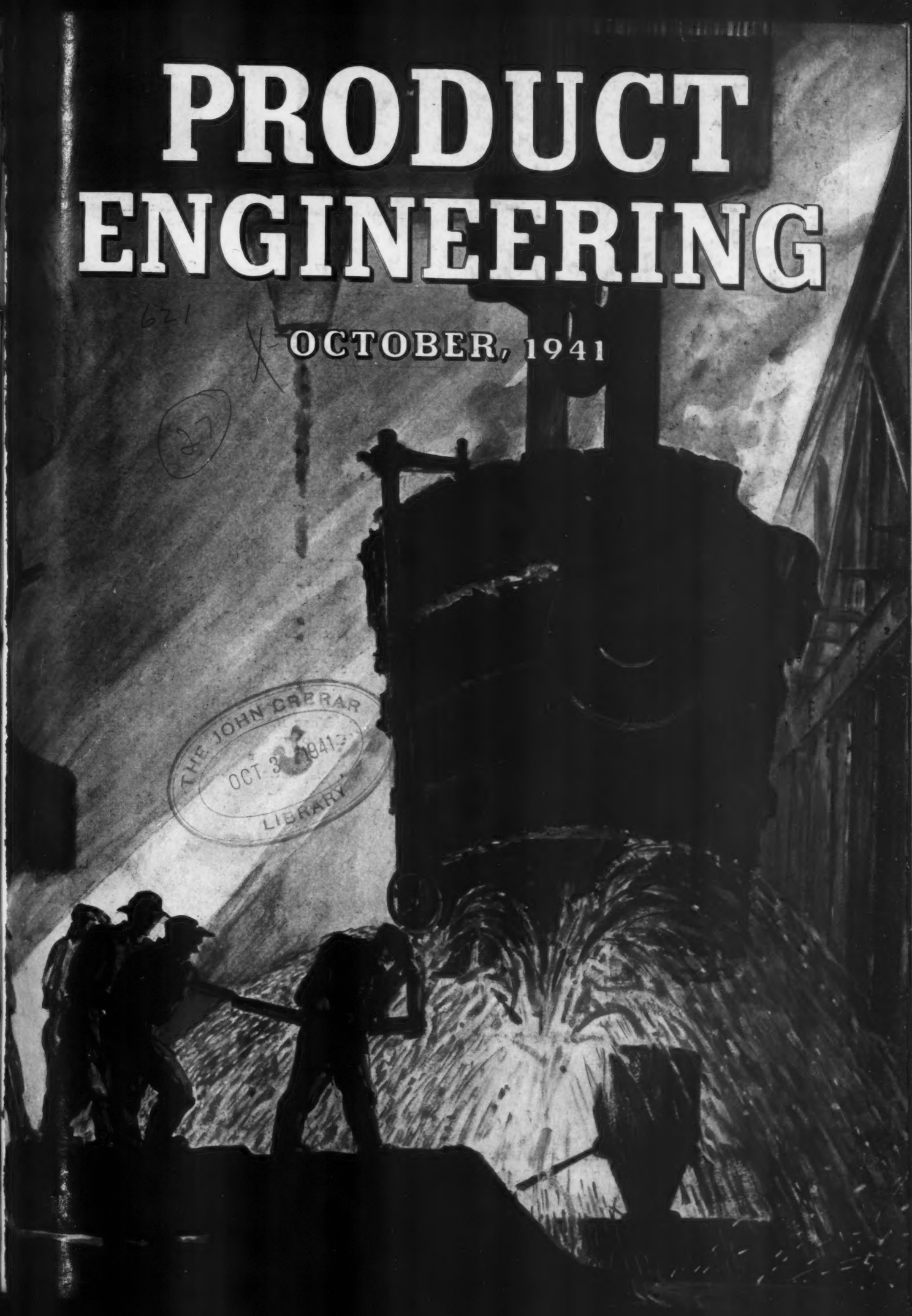
OCTOBER, 1941



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Experience of Years

STORED UP

in Helpful Literature...

The pressing demands of the defense program call for the employment of every skill and facility at the disposal of the metal working industries.

Among the resources available is the experience of our technical staff in the solution of problems involving the use of Nickel and its alloys.

This experience has been distilled into helpful literature which deals with the selection, fabrication and uses of these materials. This printed matter is yours for the asking. You are also offered the assistance of our technical staff in solving problems of material arising from the temporary lack of Nickel.

Your inquiries addressed to the Company either for literature or personal consultation will receive prompt attention.

Nickel

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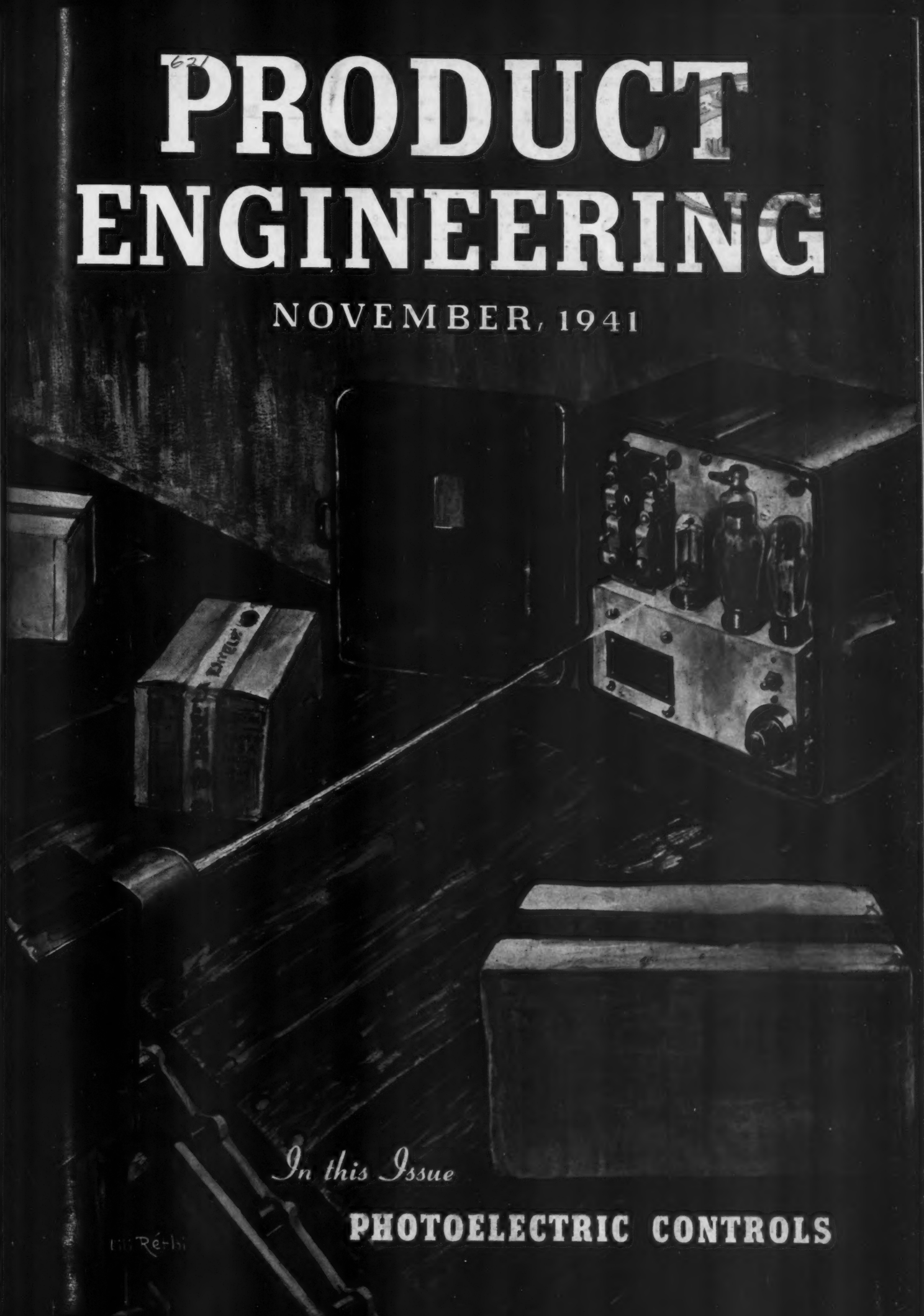
NOVEMBER, 1941



In this Issue

PHOTOELECTRIC CONTROLS

ALLOYS

Timely information about metals...
CATALOGUED for your convenience

Specific answers to many of your questions about the selection, fabrication and uses of Nickel alloys are available to you quickly from our files.

This fund of helpful information we have gathered, checked and condensed into convenient printed form. The graphs, charts and shop guides are especially useful to men handling new materials or performing unfamiliar operations . . . and to new employees. This literature is available on request.

You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. These engineers are offering timely suggestions to many vital industries during the present emergency.

Why not drop us a card asking for list of available literature. Your request for the assistance will receive prompt attention.

NICKEL

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PRODUCT ENGINEERING

DECEMBER, 1941

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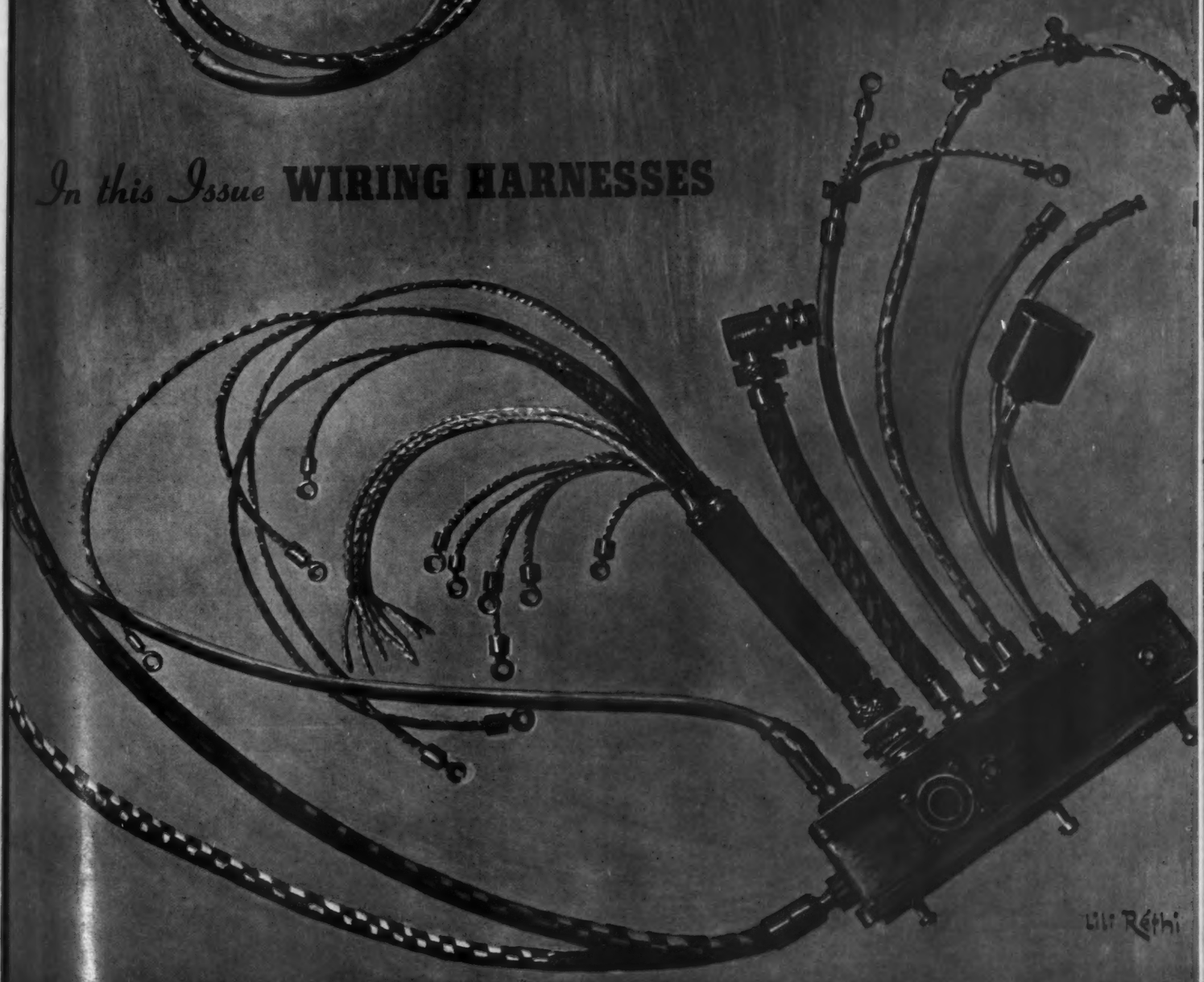
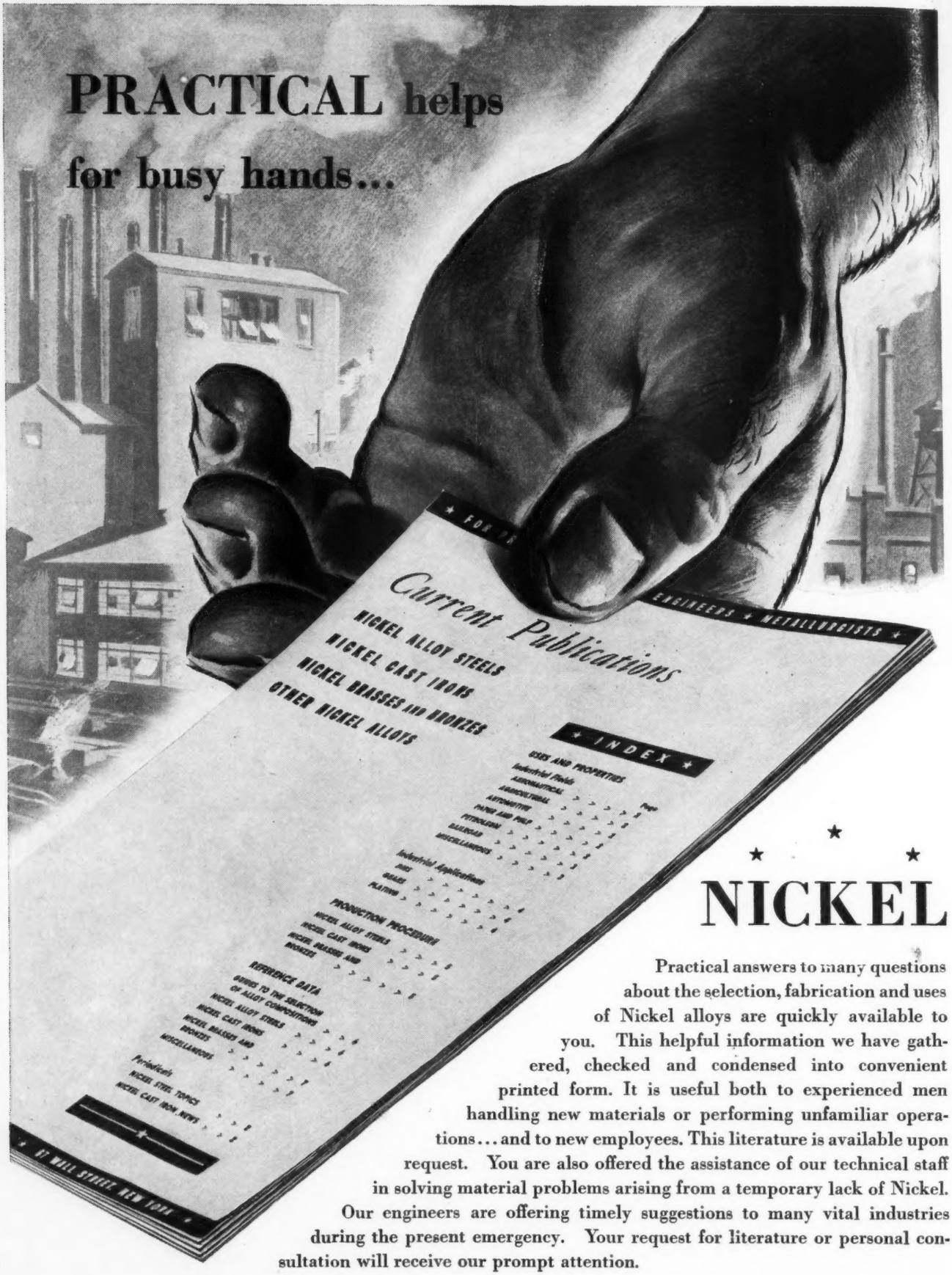
In this Issue **WIRING HARNESSES**





NICKEL

Practical answers to many questions about the selection, fabrication and uses of Nickel alloys are quickly available to you. This helpful information we have gathered, checked and condensed into convenient printed form. It is useful both to experienced men handling new materials or performing unfamiliar operations... and to new employees. This literature is available upon request. You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. Our engineers are offering timely suggestions to many vital industries during the present emergency. Your request for literature or personal consultation will receive our prompt attention.

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PRODUCT ENGINEERING

VOLUME XII DECEMBER, 1941 NUMBER 12

What's Coming—

"What steel shall I specify for the spring?" That is a common question, and a comprehensive answer to it will be found in the article "Steel for Springs," by H. Carlson, chief engineer of Lee Spring Company, the first installment of which will appear in January. Another outstanding article in that number will be "Color for Efficiency," by Arthur A. Brainard of Philadelphia Electric Company and Matt Denning of DuPont, wherein it will be shown, by four color illustrations, how proper color in machine tools contributes to the efficiency and safety of their operation. "Patent Procedure," by Miles Henninger of Allis Chalmers Manufacturing Company will tell the readers how to take advantage of the facilities of the U. S. Patent Office. This will be the first of a series of articles wherein the author clarifies Patent Office procedures and explains some of the complexities of the procedures of investigating and getting patents. Other articles will include "Photo Tracing," "Dynamic Balancing," and an insert on materials.

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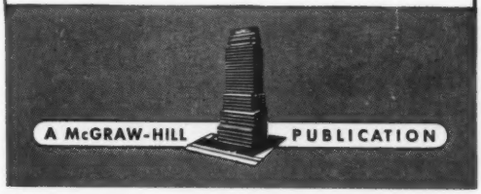

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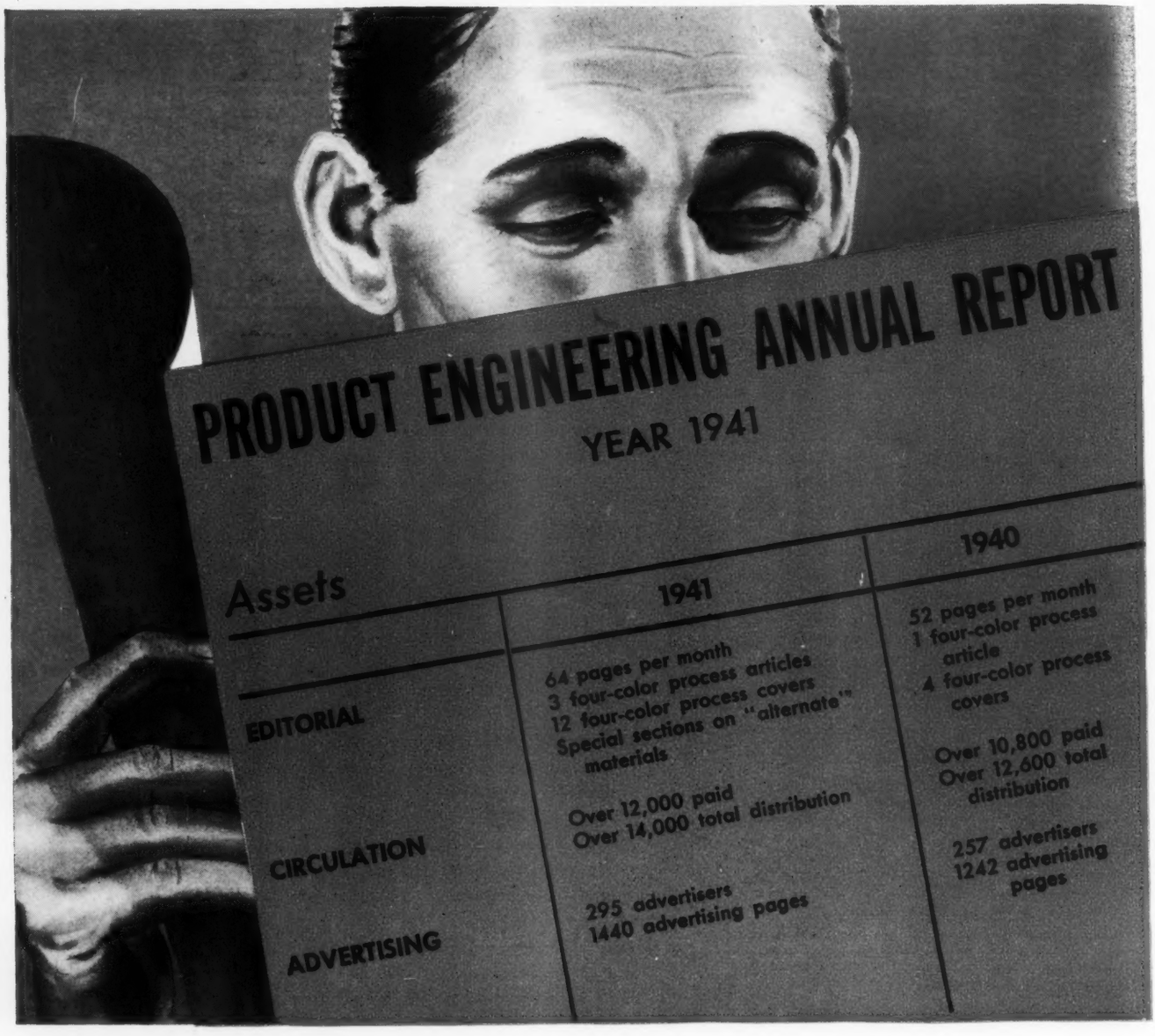

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in the

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ENGINEERING SOCIETIES

Welding Society Awards Miller And Lincoln Medals

Presentation of the 1941 Miller Memorial Award and the Lincoln Gold Medal for 1940-41 featured the session of Oct. 20 of the American Welding Society's Annual Meeting at Philadelphia, Pa. The Samuel Wylie Miller Memorial Medal was awarded to David Arnott, vice-president and chief surveyor of the American Bureau of Shipping, New York City, and second vice-president of the American Welding Society. Award of the Lincoln Gold Medal was made to Robert H. Aborn, member of the staff of the Research Laboratory of the United States Steel Corp., Kearny, N. J.

The award of the Miller Medal was made for conspicuous contributions to the art and science of welding during Mr. Arnott's long service with the American Bureau of Shipping which he joined in 1918. Mr. Arnott has many technical affiliations and has written extensively on load lines and the safety of life at sea.

The Lincoln Award, which is presented each year for the paper which contributes most to the year's development of welding, was made for "Metallurgical Changes at Welded Joints and the Weldability of Steels," published in the October, 1940 issue of "The Welding Journal."

A. S. M. E. Will Hold Clinic on Conservation of Materials

At a special feature of its Annual Meeting in New York City, the American Society of Mechanical Engineers, on Tuesday, December 2, will hold a Clinic on the Conservation and Reclamation of Materials, according to R. M. Gates, president of Air Preheater Company, who will head the Clinic Committee. Mr. Gates said that the Clinic would answer questions asked by members of the Society and any other persons interested in the vital problem of saving materials and devising methods for salvaging scrap and used articles. Questions are being solicited in advance by circularizing members of the Society. Answers will be prepared in advance by a panel of experts.

The Clinic will be preceded by brief papers giving case histories of conservation and reclamation programs actually in progress in small and large plants. After the subject has been opened up by these papers, the panel of experts will take over. It will be headed by an interlocutor who will put the questions to the members of the panel best qualified by experience to answer them. Arrangements are being made to publish the questions and answers in the Society's Journal.

D. Robert Yarnall Selected as Recipient of Hoover Medal

Announcement has been made that D. Robert Yarnall, mechanical engineer of Philadelphia, Pa., has been selected as the fifth recipient of the Hoover Medal, which will be presented to Mr. Yarnall during the Annual Meeting of the American Society of Mechanical Engineers in New York City, December 1-5. The medal is accompanied by the following citation:

"D. Robert Yarnall, humanitarian, engineer, and a leader in the engineering profession, who rendered outstanding service as a member of a mission that fed the children of Germany at the end of the World War and that is now aiding refugees in this country and Europe and providing food and relief for the children and mothers of France. These distinguished public services have earned for him the Hoover Medal for 1941."

Plastics Committee Works to Aid Government

Noting that specifications are playing an increasingly important role in the industrial application of plastics, the Bulletin of the Society of the Plastics Industry announces that a technical committee is already at work with the U. S. Government Federal Specifications Committee. The Society, through technical committees, will work on technical problems. As an example, a Society Technical Committee will work with a similar technical group, selected from the aircraft industry, to discuss the possible further applications of plastics in aircraft. The potential structural uses of plastics will be explored. Permanent records will be kept for reference for the Plastic Industry and for outsiders seeking such data.

E. C. P. D. Makes Recommendations for Engineering Curricula

At the Ninth Annual Meeting of the Engineers' Council for Professional Development, held October 30 in New York City, the Committee on Engineering Schools announced that a total of 461 engineering curricula at 129 colleges and universities in the continental United States have now been accredited by it. The committee also recommended that the short engineering courses provided by the Engineering Defense Training program should not receive credit toward degrees, pointing out that this would interfere with the primary objective of the courses. Attention was called to the increase in engineering schools operated for private profit and granting engineers degrees under existing state laws. A year's study in such schools, in the opinion of the committee, is not equivalent to a year in an accredited curriculum. The committee further noted that the Defense Program has highlighted the lack in the United States of facilities for technical education of a grade between the engineering college and the vocational school. A new E.C.P.D. guidance booklet "Engineering As a Career," is expected to be available soon.

Meetings

American Society of Mechanical Engineers—Annual Meeting, Hotel Astor, New York, N. Y., Dec. 1–5. C. E. Davies, secretary, 29 W. 39th St., New York, N. Y.

Chemical Exposition—18th Exposition of Chemical Industries, Grand Central Palace, New York, N. Y., Dec. 1–6. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

Society of Automotive Engineers—Annual Meeting and Engineering Display, Book Cadillac Hotel, Detroit, Mich., Jan. 12–16, 1942. John A. C. Warner, secretary, 29 W. 39th St., New York, N. Y.

American Society of Heating and Ventilating Engineers—Annual Meeting and 7th International Exposition, Commercial Museum, Philadelphia, Pa., Jan. 26–30, 1942. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

No. 2 of a series designed to help Industry prepare for the day when "Defense Production Stops"

"But . . . WHEN DEFENSE PRODUCTION STOPS?"

"Will my company be ready with new products, new equipment, new designs to compete in the coming scramble for business?"

It isn't too soon to think about that, now that the defense load is shifting from "design engineering" to "mass production". When defense production stops, it will stop suddenly. It takes time to develop new ideas.

Though our increased manufacturing facilities are now devoted all-out to meeting vital defense needs, we want to help those companies for the future.

To such companies the facilities of our engineering department are wide open: To design the necessary Cone-Drive gearing for you, without charge or obligation.

You will find that Cone-Drive gearing will improve your designs and cut your costs with its greater load carrying capacity, greater compactness and longer life.

We will be glad to send you a bulletin on "Why Cone-Drive Gearing". #CW-41A (For executives); CW-41 (For design engineers).

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MORSE *positive* DRIVES

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ZINC IN DEFENSE-

NO. 3 OF A SERIE

PAINT SERVES DEFENSE IN:

Aircraft
Camouflaging
Cantonments
Combat Cars
Guns
Industrial Plants
Marine Equipment
Pontoon Bridges
Scout Cars
Shells
Troop Carriers—
And In Many Other Ways

U. S. ARMY AIR CORPS PHOTO

THE ELEMENTS ARE ALSO DESTRUCTIVE!

The primary requirement of many defense items is the ability to withstand the destructive forces of war. But there are other forms of attack to be reckoned with as well—rust, chemical corrosion, and the destructive forces of the elements on land and sea. The answer to these problems is paint. Uncle Sam is faced with the biggest painting job in the history of the country—a job in which zinc pigments are playing a vital part.

No man can estimate the amount of zinc pigments needed to complete this job, but the final figure will be a staggering one. The camouflage painting, shown above, is only a small part of the story. Everything from shells to ships, from cannon to cantonments has already been covered by hundreds of exacting Government paint specifications—requiring quantities of zinc sulfide, zinc oxide, lithopone, zinc dust and zinc chromate.

Listed above are typical uses for paint coatings in defense. Zinc pigments are doing the same job in these defense paints as they have been doing in the paint industry year in and year out—protecting property and improving sanitation, too, when that is a factor. It is the increased demand for each of the zinc consuming products required in the Defense Program which is making it difficult for non-defense users to obtain all of the zinc they would like to use. This is part of the price that must be paid for national security.

PAINT
DIE CASTING
CERAMICS
BRASS
METAL SPRAYING
GALVANIZING
PHARMACEUTICALS
NICKEL SILVER
NO. 1 HULL PLATES
NO. 2 RUBBER

PAINT PROTECTS AMERICA
ZINC PROTECTS PAINT

THE NEW JERSEY ZINC COMPANY

MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS

NO. 9

ALUMINUM, DEFENSE, AND YOU

SIX MORE PLANTS IN FIVE STATES ON THE WAY

DEFENSE PLANT CORPORATION OWNS THEM. We've been designated to build them . . . fast.

Actually, when the names went on the dotted lines of the contract on August 19, we had already placed more than $16,000,000 worth of orders for some of the equipment and materials it takes longest to make and get.

FIVE OF THESE PLANTS will smelt aluminum. Their combined capacity is planned for more than 500,000,000 pounds a year, which is greater than the nation's entire production of aluminum in 1940. Locations: Massena, N. Y., Spokane, Wash., Troutdale, Ore., Los Angeles, and in the State of Arkansas.

The sixth plant will refine alumina from bauxite. Its billion-pounds-a-year capacity adds 58% to the nation's alumina capacity. It will be located at Bauxite, Arkansas.

HOW GOES CONSTRUCTION? At this writing, as fast as title is secured to the sites, contracts are being let for grading and foundations so as to be ready for the structural steel, which is coming as rapidly as it can be gotten.

What is more important, the aluminum plants are scheduled to deliver ingot by the summer of 1942; the refining plant to deliver alumina in early summer, 1942.

WE'VE ASSIGNED a large staff of men full time to headquarters engineering, purchasing, and accounting on this government building job.

We're sending competent and experienced management men out on these jobs as superintendents and other staff executives on construction, and for subsequent operation of such of these plants as we are designated to operate.

EVERY KNOWN IMPROVEMENT in design and construction and equipment is being incorporated in these plants. We intend that every dollar that will be spent shall be the best dollar's worth that experience can build. We do not make one cent of profit from this assigned job of construction.

We think we know how to get the government value-received for its money, because we are completing the expenditure of more than $200,000,000 of our own money in an expansion program which started after the beginning of the present war. Some of this expenditure is in new alumina and aluminum plants which will bring our own Alcoa capacity up to more than 700,000,000 pounds a year. The remainder is in tremendous expansion of facilities for fabricating every form of aluminum.

DEFENSE, GENTLEMEN, is getting its aluminum.

ALUMINUM COMPANY OF AMERICA

MULTIPLY THE SERVICE LIFE

OF VITAL WEARING SURFACES WITH...

With replacement parts at a premium, it's more important than ever to get the longest possible service life out of vital wearing surfaces. That's why so many manufacturers are relying on the Airco Flame Hardening Process to do just that. For this proved process increases the life of wearing parts immeasurably by hardening the surface — yet the core retains its original toughness and shock-resistance. Sprockets, gear teeth, wearing surfaces, shafts and a multitude of shapes regardless of size, are quickly and economically hardened for longer life this modern Airco way.

The facilities of Airco's Applied Engineering Department are available to assist Airco customers get maximum surface wearing life. Write us about your individual problems.

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Anything and Everything for GAS WELDING or CUTTING and ARC WELDING

The Growing Preference

for Oilgear Equipped Machines

It's a matter of factual record that machines which have been equipped with Oilgear Fluid Power meet with exceptional user acceptance everywhere. Many machine tool manufacturers who have standardized on Oilgear Equipment for the past 10 to 17 years write, that today, more than ever before, the Oilgear Systems on their machines give them a powerful selling leverage. Moreover, several manufacturers have turned their sidelines into headliners by equipping them with Oilgear.

There are a host of reasons why. From the standpoint of the user, Oilgear Fluid Power gives the operator faster and more accurate control; it gives the machine the extra speed and reserves of power needed to carry today's heavy production load; and Oilgear minimizes those "times out" for maintenance and repair which slice the peaks off production curves. Output and more output is the word today, and Oilgear powers up machines to give their very maximum.

Then, from the standpoint of the manufacturer, Oilgear means a power problem *solved;* it means a greater measure of dependability and greater protection to the manufacturer's and the user's reputation.

Before you buy Fluid Power Equipment, look into Oilgear Fluid Power. Get the whole story. With all the facts right at hand, you'll see *why* the swiftly growing preference for Oilgear equipped machines and machine tools. Use the coupon below for complete details. THE OILGEAR COMPANY, 1311 W. Bruce St., Milwaukee, Wis.

Feeds • Pumps • Cylinders • Valves • Motors • Transmissions Horizontal and Vertical Broaching Machines • Horizontal and Vertical Presses • Custom Built Machines

Baldwin Southwark 4000 ton Forming Press. Equipped with Oilgear 100 H.P. Two-Way Variable Displacement Pumps.

25,000

Over 25,000 H.P. (normal H.P. rating) of Oilgear Fluid Power Units put on presses of 6 leading domestic press manufacturers.

17 *leading* press manufacturers as well as other smaller ones now use Oilgear Fluid Power Equipment.

Rockford Machine Tool Company "Hy-Draul" Vertical Slotter. Uses Oilgear Variable Displacement Pump, Combination Valve and Cylinder.

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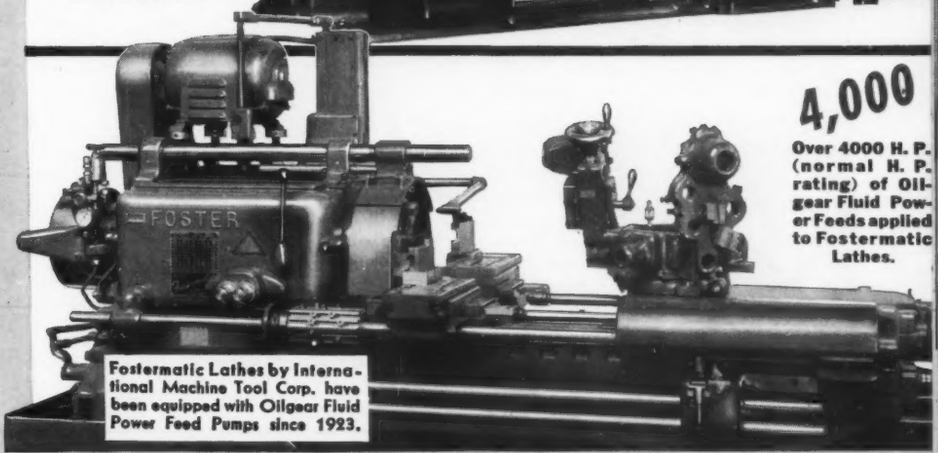
Over 9,000 H.P. (normal H.P. rating) of Oilgear Fluid Power Units put on Rockford Planers and Slotters.



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Over 4000 H.P. (normal H.P. rating) of Oilgear Fluid Power Feeds applied to Fostermatic Lathes.

Fostermatic Lathes by International Machine Tool Corp. have been equipped with Oilgear Fluid Power Feed Pumps since 1923.

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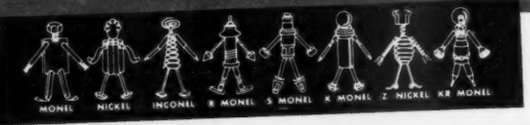


..each with a DIFFERENT PLUS!

Extra hardness, heat-resistance, non-magnetism, free-cutting and other qualities available in INCO Nickel Alloys

You doubtless know that Monel combines *strength* with excellent *resistance* to *corrosion*. But do you know that newer members of the INCO Nickel Alloy family combine varying degrees of strength with other useful properties? For example:

One of these metals is extra hard and non-galling; two are free-machining, two heat-treatable, one is non-magnetic, one especially adapted for high temperature service, while several make excellent spring materials for use under different conditions.

Knowing the *individual* characteristics of the INCO Nickel Alloys, will better enable you to meet the requirements of defense and other contracts. Write for the booklet, "*Individualized* INCO NICKEL ALLOYS." Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

	INDIVIDUALIZED CHARACTERISTICS	AVERAGE MECHANICAL PROPERTIES					
		Condition	Tensile Strength 1000 psi.	Yield Strength 1000 psi.	Elongation in 2 in. per cent	Hardness Brinell 3000 kg.	Impact Strength Izod
MONEL* 2/3 Nickel 1/3 Copper	GENERAL PURPOSE ALLOY Corrosion Resistance, Strength, Hardness, Toughness. Attractive Silvery White Color.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	75 90 100 110	35 50 80 100	40 35 25 5	125 150 190 240	105 110 95
"R" MONEL* Contains the addition of .035% sulfur—	FREE CUTTING For High Speed Machining.	Hot-rolled Cold-drawn	85 90	45 75	35 25	145 180	96 99
"K" MONEL* Contains the addition of 2.75% Aluminum	EXTRA STRENGTH AND HARDNESS comparable to heat treated alloy steel. Heat Treatable. Non-magnetic.	Hot-rolled: As-rolled Hot-rolled: Heat-treated Cold-drawn: As-drawn Cold-drawn: Heat-treated	100 150 115 155	45 110 85 115	40 25 25 20	160 280 210 290	120+ 40 56 26
"KR" MONEL*	FREE CUTTING Extra Strength and Hardness. Heat Treatable. Non-magnetic.	Hot-rolled: As-rolled Hot-rolled: Heat-treated Cold-drawn: As-drawn Cold-drawn: Heat-treated	105 150 115 155	65 105 85 115	40 25 25 25	185 280 215 290	
"S" MONEL* Contains the addition of 4% silicon	EXTRA HARDNESS Non-galling.	Sand-cast: Annealed Sand-cast: As-cast Sand-cast: Heat-treated	90 130 130	70 100 100	3 2 2	275 320 350	
NICKEL 99.4% Nickel	CORROSION RESISTANCE Protection for Pure Products. Magnetic below 680° F. Good Electrical Conductivity.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	70 75 95 105	20 25 70 95	40 40 25 5	100 110 170 210	120+ 120+ 120+
"Z" NICKEL* 98% Nickel	EXTRA STRENGTH AND HARDNESS Heat Treatable. Excellent Spring Properties. Good Electrical Conductivity. Magnetic.	Hot-rolled: As-rolled Hot-rolled: Heat-treated Cold-drawn: As-drawn Cold-drawn: Heat-treated	105 170 120 175	50 130 90 135	35 15 25 15	180 320 220 340	120+ 25 120+ 25
INCONEL* 80% Nickel 14% Chrome Balance—Iron	HEAT RESISTANCE Retains Strength. Resists Oxidation. High Corrosion Resistance.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	85 100 115 135	35 60 90 110	45 35 20 5	150 180 200 260	120+ 110 85

*"MONEL" and other trade-marks which have an asterisk associated with them are trade-marks of The International Nickel Company, Inc.

INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • NICKEL • "Z" NICKEL

Sheet...Strip...Rod...Tubing...Wire...Castings

Engineer "sticks his neck out!"

YES SIR! An engineer who uses any but the best motors on the machines he designs and builds is "sticking his neck out . . ."

For the wise engineer knows that motors are the *heart* of machine tools. He knows that his machines are *no better* than the motors that power them!

This is the reason why more and more design engineers today are switching to modern Allis-Chalmers Lo-Maintenance Motors!

Low-Maintenance Motors Pay An Extra Dividend!

The story behind these motors is an interesting one—one it will pay you to get acquainted with. For in Lo-Maintenance Motors you get such outstanding features as a stator that's twistless and distortionless... a rotor that's indestructible . . . a frame that's made of special high carbon steel for greatest protection.

What's more—you get all-'round performance that's "more than the rating on the nameplate"—an *extra* operation dividend that the design engineer is glad to pass on to the purchasers of his machines.

To get the facts about Allis-Chalmers Lo-Maintenance Motors, call the district office near you...or write Allis-Chalmers, Milwaukee, Wis.

A1388

THE DESIGN ENGINEER OF THIS Stoker-Unit drilling machine has made sure he hasn't "stuck his neck out" on performance. With three Allis-Chalmers Lo-Maintenance Motors powering the machine, he knows he is giving his customers an "extra dividend" in dependable, low-cost motor service.

ALLIS-CHALMERS LO-MAINTENANCE MOTORS

A COMPLETE LINE FOR EVERY PURPOSE...ONE-HALF HORSEPOWER AND U

ACCESSORY EQUIPMENT
BRIDGEPORT, CONNECTICUT

APPLIANCE WIRING AND CONTROL DEVICES VITALLY IMPORTANT TO YOUR PRODUCT

HOW LONG SHOULD A CORD SET BE?

(A New Answer in the Light of Present-day Restrictions)

General Electric Accessory Equipment engineers have always advocated cord sets ***long enough for the convenient use of the appliances to which they are attached.*** In terms of user satisfaction and increased sales appeal, this answer has been logical and fair.

Today, however, the production of portable cords for non-defense requirements is substantially restricted, and sensible conservation is indicated. To realize necessary savings and provide for the largest possible number of appliances for domestic consumption, ***we suggest using minimum-length cord sets until production restrictions are removed.***

This plan will permit the manufacture of more appliances for domestic use and, where cord is a limiting factor, it will permit you to serve a broader market and satisfy more customers.

WHAT IS "MINIMUM LENGTH" FOR YOUR PRODUCT?

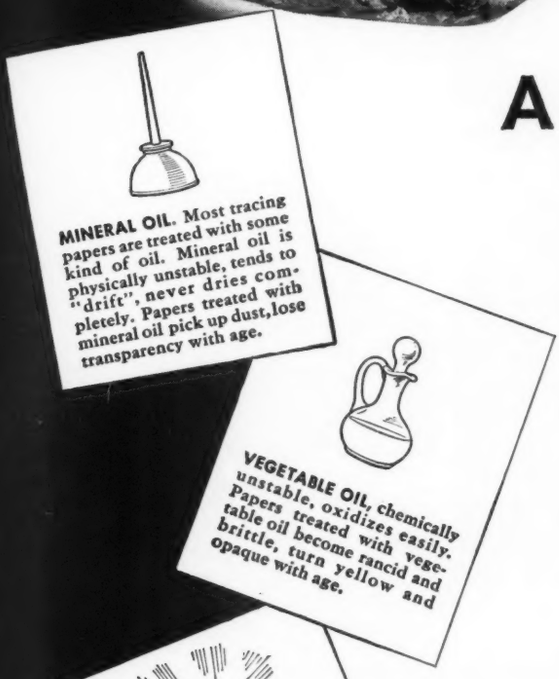
We suggest the following "minimum length" cord sets for your consideration:

PRODUCT	APPROXIMATE PRESENT LENGTH	SUGGESTED MINIMUM
Vacuum Cleaners	20	15
Electric Clocks	6	3
Washers	8	5
Refrigerators (Outside of box)	6	3
Shavers	6	4
Heating Appliances (Other than flat irons)	7	4

At present the only alternative to curtailment in length is reduction in the number of cord sets available for non-defense uses.

G-E CORD SETS
No matter what length cord sets you use, be sure they're protected with G-E Molded-on Rubber Plugs and G-E Strain Reliefs or Connectors. Because they resist breakage they conserve material . . . protect good will.
A G-E Accessory Equipment representative is ready to discuss your cord set requirements and furnish helpful information on all G-E Accessory Devices. Write to Section Q-142B, Appliance and Merchandise Department, General Electric Co., Bridgeport, Connecticut.

GENERAL ELECTRIC


MINERAL OIL. Most tracing papers are treated with some kind of oil. Mineral oil is physically unstable, tends to "drift", never dries completely. Papers treated with mineral oil pick up dust, lose transparency with age.
VEGETABLE OIL, chemically unstable, oxidizes easily. Papers treated with vegetable oil become rancid and brittle, turn yellow and opaque with age.
ALBANITE is a crystal-clear synthetic solid, free from oil and wax, physically and chemically inert. Because of this new stabilized transparentizing agent Albanene is unaffected by harsh climates —will not oxidize with age, become brittle or lose transparency.

A new synthetic solid gives you this *permanent* tracing paper

A remarkable new transparentizing agent developed in the K&E laboratories—produces this truly permanent tracing paper! ALBANENE is made of 100% long fiber pure white rags—treated with *Albanite*—a new crystal clear synthetic solid, physically and chemically inert. ALBANENE will not oxidize, become brittle or lose transparency with age.

Equally important, ALBANENE has an excellent drawing surface that takes ink or pencil beautifully and erases with ease... a high degree of transparency that makes tracing simple and produces strong sharp blueprints... extra strength to stand up under constant corrections, filing and rough handling. ALBANENE has *all* the working qualities you've always wanted—and *it will retain all these characteristics indefinitely.*

Make ALBANENE "prove it" on your own drawing board. Ask your K&E dealer or write us for an illustrated brochure and generous working sample.

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Completely Cold Forged

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TRADE MARK *fibro forged* SOCKET SCREWS

THE HOLO-KROME SCREW CORP. HARTFORD, CONN., U.S.A.

Advertisement DECEMBER, 1941

COPPER ALLOY BULLETIN

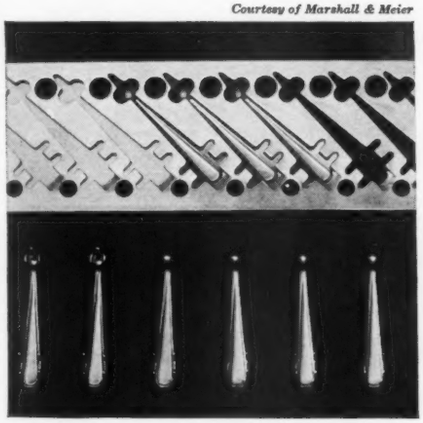
REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Die-Stamped Parts Readily Produced From Brass Sheet

Small parts of accurate dimensions, such as clips for pens, pencils, and pocket thermometers, can be economically die-stamped from brass sheet of controlled quality. The accompanying illustration indicates how easily clips can be formed from Bridgeport brass sheet by multiple die-stamping operations. As the brass sheet is fed into the press, the trade name is stamped on the metal, the contour of the part is shaped, and the clip is punched out in rough finished form. Because of the clean cutting character of Bridgeport brass sheet, the rough stamped parts require no intermediate finishing. They are fed directly into a press designed to shape and "ball" the clip end in a single operation.

Courtesy of Marshall & Meier



Duronze* III Resists Attack by Fuel Oils

Exceptionally high corrosion resistance of Duronze III is demonstrated by its successful performance in the screw machine part illustrated, which is used in assembly of aircraft carburetors. In addition to withstanding the severe corrosive attack of hot gasoline in this application, Duronze III has the further advantages of very high strength, smooth, hard surface, and light weight.

Duronze III also displays high resistance to the action of the elements, sea water, dilute acids, and many other chemicals.

Proper Control of Annealing Is Essential in Brass Fabrication

Operation is One of the Most Important in its Effect on Strength, Ductility, and Other Characteristics of Brass

One of the reasons why brass is so useful is that the physical properties of a given alloy can be varied over a wide range, depending upon whether it has been finished by annealing or cold working, and further depending upon the severity of these operations.

In order that the properties of a batch be sufficiently uniform for the processes to which it is to be subjected, it is important that these operations be carefully controlled.

Too much emphasis cannot be placed upon the importance of the annealing or heat treating operation as applied to the brasses. Unlike steel, brass in its soft or annealed condition is a metal of moderate strength and excellent ductility. However, upon cold working, such as rolling or drawing, brass becomes stiff and hard, its tensile strength rising rapidly with decreasing ductility. Cold worked material can be made soft and ductile again, however, by annealing or raising the metal to a red heat. In other words, the nature and physical properties of brass depend mainly upon the final treatment which it receives: namely, annealing (softening) or cold working (hardening).

Relief Annealing

Since hardness and strength in brass are artificially induced by cold working, it often happens that finished articles made by forming, drawing or stamping contain serious stresses which may let go under certain conditions causing cracks or breaks in the material. Such stresses can generally be eliminated by relief annealing at a temperature too low for recrystallization or softening. Relief annealing is used in many cases where articles are to be kept in storage for long periods of time.

True annealing takes place when the material is heated at a sufficiently high temperature so that recrystallization actually takes place. In general, this change in structure is accompanied by softening. With rising temperatures of anneal, the crystals grow larger, with corresponding increased ductility and lower tensile strength.

Under the microscope the brass shows a crystalline structure—the size of the crystals increasing with rising temperature. By controlling the grain size, brass of various degrees of softness can be made. The coarse-grained material presents a rough surface after stretching resulting from forming or cupping. If it is necessary to polish or buff such a surface, considerable cutting down must take place, accompanied by higher finishing costs. A fine-grained material requires much less polishing and results in a better finish. A medium-sized structure is desirable for ordinary drawing operations.

(Above) Annealed yellow brass, medium grain size, Mag. 75X. Tensile strength about 45,000 pounds per square inch.

(Above) Cold worked yellow brass, Mag. 75X. Tensile strength about 62,000 pounds per square inch.

Types of Equipment

Although the type of furnace and nature of the fuel are important from an operating standpoint, nevertheless almost any annealing equipment will produce the desired results if careful attention is given to good annealing practice. Best results are obtained with a furnace large enough so that the batch of metal to be annealed can be brought up close to the indicated furnace temperature. In cases where the annealing equipment is too small, the common practice is to rush the annealing by maintaining the furnace considerably higher than the desired annealing temperature and pulling the material out of the furnace before it attains furnace temperature. Such practice is dangerous because of the uncertain time element—a little longer period in the furnace may bring the metal up to a higher temperature than required, while a shorter period may result in only part of the material attaining the annealing temperature. In other words, non-uniformity results from lack of annealing facilities.

Certain brass alloys, especially those which contain copper above 85%, oxidize rapidly when exposed to the air when in a

(Continued on page 2, column 2)

COPPER ALLOY BULLETIN

ALLOYS OF COPPER

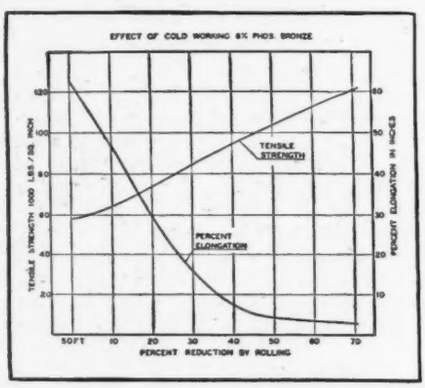
This is the twenty-ninth of a series of articles on the properties and uses of the copper alloys, and continues the subject of the copper-tin alloys.

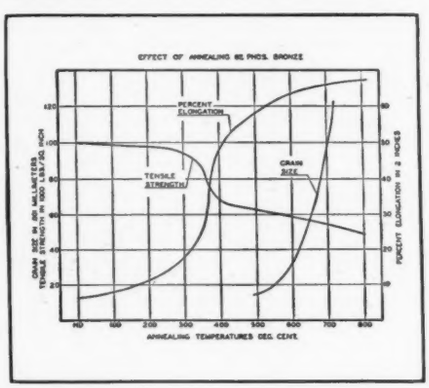
PROPERTIES OF COPPER-TIN ALLOYS

The properties of the copper-tin alloys which have made them particularly useful are their combination of good fatigue life, corrosion resistance and spring characteristics. The last item is difficult to define exactly but seems to be related to high elastic limit and resistance to creep at room temperature. This combination of properties is responsible for the use of phosphor bronze clips in almost all types of electrical switch contacts. In order to secure these mechanical properties it is necessary to furnish the strip or wire in the cold worked condition.

Because of their cost the alloys have only been used when cheaper alloys could not be used. This is unfortunate for the alloys have other properties which are highly desirable. In the annealed condition the 8% tin alloy has an excellent combination of ductility and strength, being actually superior to cartridge brass in those respects. These properties lead to the use of phosphor bronze in some of the highest quality thermostatic bellows, where ability to withstand severe stretching operations combined with good tensile strength and elastic properties are important.

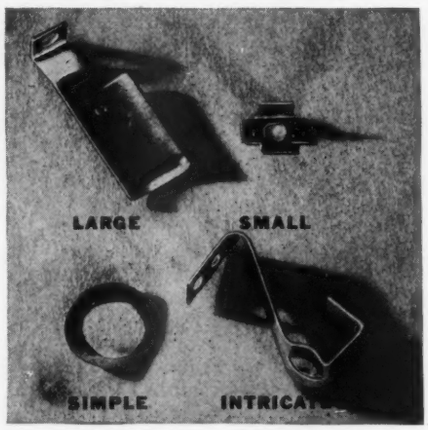
It is apparent from the accompanying curves that the alloy has many attractive properties which have not been fully exploited because of the cost of the material. These curves cover the mechanical properties of the 8% tin phosphor bronze as affected by cold working and annealing.





Phosphor Bronze Is Readily Fabricated

The ease with which Bridgeport New Phosphor Bronze is adaptable to the fabrication of many types of parts—large or small, simple, or intricate—is indicated by the accompanying photograph of typical phosphor bronze items. Bridgeport's carefully controlled methods of processing assure a phosphor bronze with the qualities that contribute to ease of fabrication as well as to long life and lasting resilience.



Annealing of Brass

(*Continued from page 1, column 3*)

red hot condition. Oxidation can be prevented by using non-oxidizing furnace equipment. Where this is not available the oxidized surface can be removed by pickling in a dilute sulphuric acid pickle. The best practice, of course, is to prevent oxidation in the first place.

NEW DEVELOPMENTS

An automatic thread-milling machine is said to be designed to produce internal and external threads of a high degree of accuracy at rapid speeds. Manufacturer says that the operator need only load and unload the machine and actuate the starting lever, all other machine functions being performed automatically. **(No. 270)**

A shell-spraying machine is provided with an electric eye control that shuts off the spray when there is no shell in the work holder, it is reported. Machine coats exterior and interior surfaces in one operation. **(No. 271)**

A pneumatic comparator gage is reported to amplify small dimensions accurately and show them on a dial type indicator. According to the maker, the gage is especially suitable for production work, because the "wear" factor is eliminated. The measuring points are actually air nozzles, which do not touch the piece being gaged, and are therefore not subject to wear. **(No. 272)**

A new precision machine is reported to be especially adapted to accurate milling, boring, facing, and routing operations in tool, die, and machine shops. V-belt drive provides a wide range of speeds. Suggested applications include the manufacture of small parts for instruments and munitions. **(No. 273)**

A pickling agent recently placed on the market is said to have exceptional advantages in the processing of copper and copper alloys. Maker says that it can be used successfully on brasses, including leaded brass, silicon bronze, phosphor bronze, and many other copper alloys, as well as on pure copper. Among the reported advantages of the new material are rapid and thorough pickling, prevention of red stains, improved surface appearance, and reduction in the danger of attacking the metal. **(No. 274)**

A sensitizing process for copper and brass is said to permit the making of templates by photographing drawings directly on the metal surface, thus eliminating considerable hand layout time. The process, which involves coating the metal with a photographic emulsion, can be applied also to the making of nameplates, instrument dials, and similar parts, it is claimed. **(No. 275)**

A new hardness tester is provided with an attachment that simplifies testing on irregular surfaces not easy to reach with conventional instruments. Tester is of the small portable type, and is said to be adapted to both metals and finishes. **(No. 276)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

PRODUCTS OF THE BRIDGEPORT BRASS COMPANY

Executive Offices: BRIDGEPORT, CONN.—Branch Offices and Warehouses in Principal Cities

SHEETS, ROLLS, STRIPS— *Brass, bronze, copper, Duronze**, for stamping, deep drawing, forming and spinning.

CONDENSER, HEAT EXCHANGER, SUGAR TUBES— For steam surface condensers, heat exchangers, oil refineries, and process industries.

*Trade-name.

PHONO-ELECTRIC* ALLOYS— High-strength bronze trolley, messenger wire and cable.

WELDING ROD—For repairing cast iron and steel, fabricating silicon bronze tanks.

LEDRITE* ROD—For making automatic screw machine products.

BRASS "Bridgeport" CO.

Established 1865

COPPER WATER TUBE — For plumbing, heating, underground piping.

DURONZE ALLOYS — High-strength silicon bronzes for corrosion-resistant connectors, marine hardware; *hot rolled sheets* for tanks, boilers, heaters, flues, ducts, flashings.

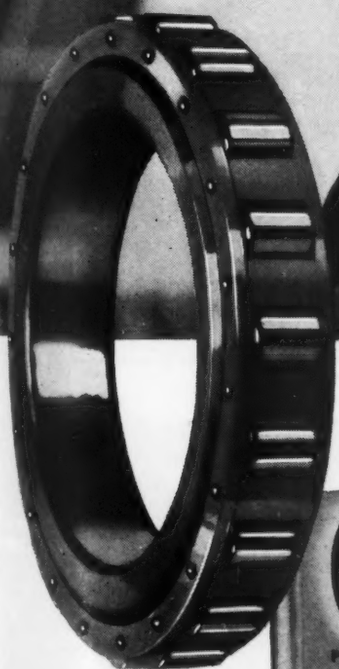
BRASS, BRONZE DURONZE WIRE— For cap and machine screws, wood screws, rivets, bolts, nuts.

FABRICATING SERVICE DEPT. —Engineering staff, special equipment for making parts or complete items.

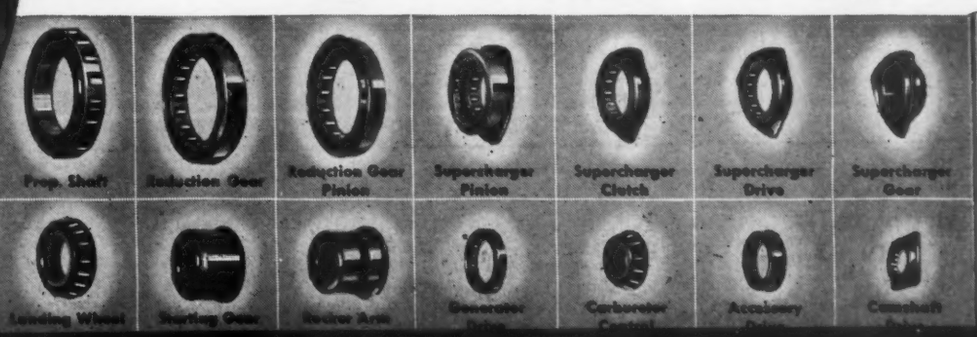
BRASS AND COPPER PIPE— "Plumrite"* for plumbing, underground and industrial services.

BRIDGEPORT BRASS

Keep 'em Flying



Propeller Shaft



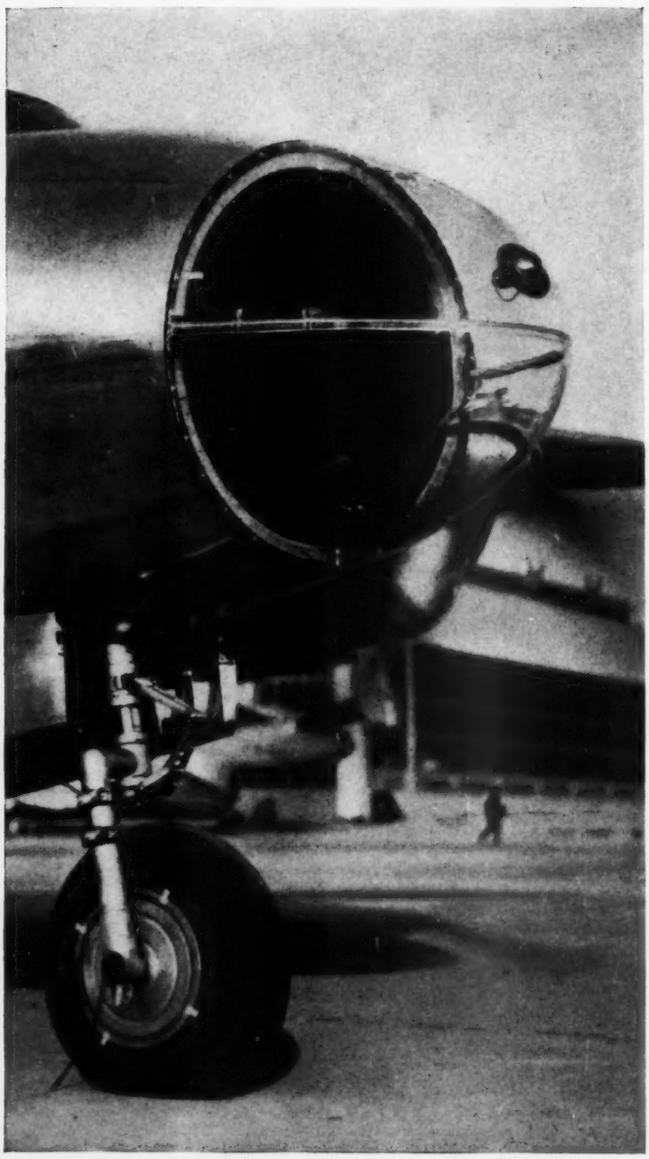
Ask for it...

An interesting full color, 4-page folder featuring Bower advantages is se-

BOWER ROLLER BEARING CO.
Detroit, Michigan

★ PLEXIGLAS and

Can Bring Permanence, Strength



• *Permanently clear* PLEXIGLAS forms this Martin B-26 nose section.

IN THE DEFENSE EFFORT, PLEXIGLAS is playing its own important part. Aircraft engineers have found PLEXIGLAS ideal for transparent cockpit enclosures, gun turrets, nose sections, and observation hatches. On the Navy's new small boats, on tanks, on a hundred other defense jobs, PLEXIGLAS and CRYSTALITE have been specified. They are strong, permanently transparent, and light in weight.

To keep pace with these demands, we are constantly increasing our production, but still we cannot supply PLEXIGLAS and CRYSTALITE to all who would like them for civilian use. They cannot now be considered substitutes for metals or for other restricted materials.

You, however, can profit from our active participation in defense production in two ways. First, when the defense effort is over, there will be more PLEXIGLAS and CRYSTALITE available for your use.

Second, because we are crowding years of experience into every month, we are now, better than ever before, able to assist you in your investigation of plastics. Let us help you prepare now for your post-war competition.

PLEXIGLAS *sheets and rods, weatherproof, shatterproof and strong, can be fabricated by bending, sawing, drilling and cementing into crystal-clear ornaments or durable industrial parts.*

CRYSTALITE *molding powders make possible moldings stronger and lighter than glass, resistant to weathering, moisture and chemical action, high in dielectric strength.*

PLEXIGLAS and CRYSTALITE are the trade-marks, Reg. U. S. Pat. Off., for the acrylic resin thermoplastics manufactured by the Rohm & Haas Company

RÖHM & HAAS

MANUFACTURERS OF LEATHER AND TEXTILE SPECIALTIES AND FINISHES . . . CRYSTAL CLEAR ACRYLIC PLASTICS

CRYSTALITE ★

and Sparkle to Your Product

CRYSTAL-CLEAR—PLEXIGLAS and CRYSTALITE bring brilliant sparkle and excellent optical qualities to any application. Clearer than glass, they "pipe" light, even around corners, for edge-lighted dials and signs. They reflect the quality of a container's contents, they enhance as well as display merchandise, they add sales appeal to your product.

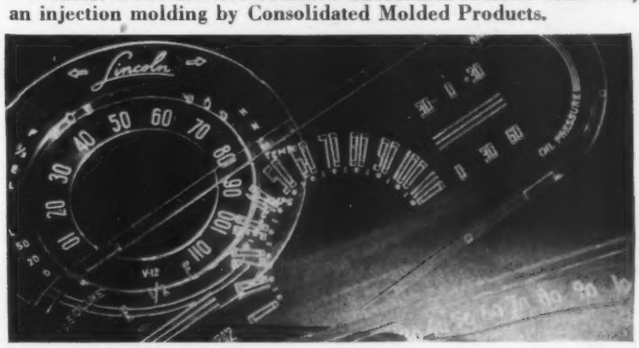
LIGHT-WEIGHT— Less than half as heavy as glass, PLEXIGLAS and CRYSTALITE can cut excess poundage from your product. Naval architects, for example, use PLEXIGLAS—and light-weight mountings —to reduce above-waterline weight in their boats.

STRONG — PLEXIGLAS and CRYSTALITE resist breakage in the manufacture, installation and shipping of your product. As safety shields in industrial equipment or merchandising displays in department stores, these sturdy plastics have proved their durability.

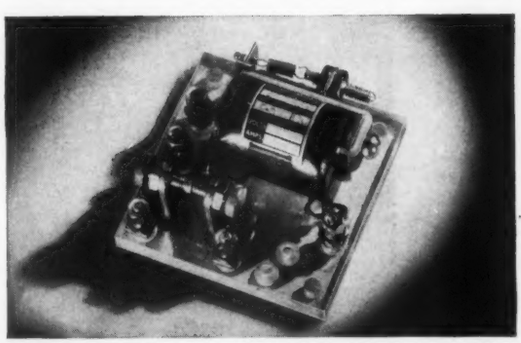
INSULATING—Especially in high voltage installations, PLEXIGLAS and CRYSTALITE resist carbon tracking and dielectric breakdown. Their low moisture absorption increases their usefulness in electrical applications.

PERMANENT—Exposure to extreme weather conditions does not discolor or warp PLEXIGLAS or CRYSTALITE. They resist the action of most chemicals, cosmetics and oils. Used indoors or out, for retail packages or mixing tanks, PLEXIGLAS and CRYSTALITE retain their clarity and lively sparkle.

• *Weather* won't discolor Pontiac's CRYSTALITE radiator ornament, an injection molding by Consolidated Molded Products.



• *Edge-lighted* dials, glare-free and rattle-free, are molded of CRYSTALITE for many modern cars.



• *Low Power Factor* dictated the use of PLEXIGLAS on Kurman Electric's high frequency relay.

• *Sparkling* PLEXIGLAS canape tongs by Creative Plastics.

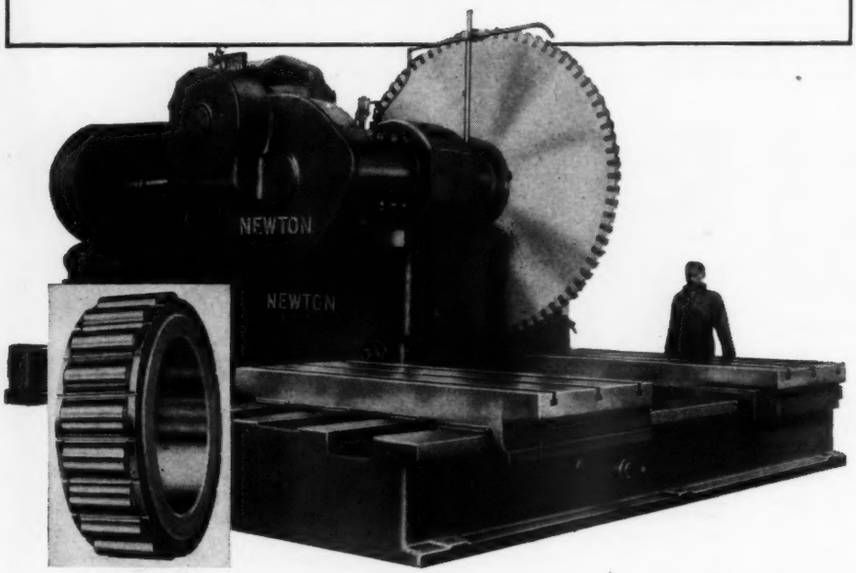
•PLEXIGLAS *rods* make durable displays for L. A. Darling.

COMPANY WASHINGTON SQUARE PHILADELPHIA, PA.

ENZYMES . . SYNTHETIC INSECTICIDES . . FUNGICIDES . . AND OTHER INDUSTRIAL CHEMICALS

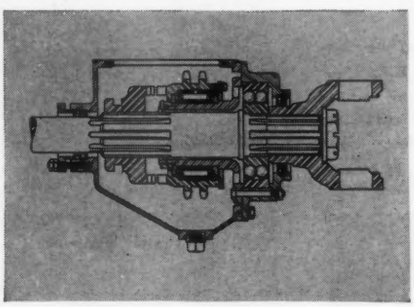
IN THE NEWS

WITH BANTAM BEARINGS

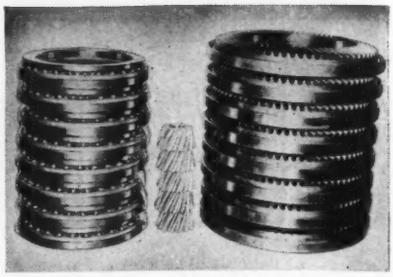


TEN-FOOT CIRCULAR BLADE is a striking feature of this Newton Cold Saw Cutting-off Machine manufactured by Consolidated Machine Tool Corporation—probably the largest machine of its type ever built. Bantam Radial Roller Bearings were selected by Consolidated for use in this giant machine because of their compactness and high load capacity. Here is a typical instance of Bantam's skill in meeting novel design requirements.

BANTAM SUPPLIES ANTI-FRICTION BEARINGS of many sizes and types to meet the requirements of Industry and Government for defense production. Because of Bantam's broad experience in the design and application of every major type of anti-friction bearing, Bantam engineers are exceptionally well qualified to undertake the solution of new and difficult bearing problems. For advice on anti-friction bearings, TURN TO BANTAM.



THIS COMPACT POWER TAKE-OFF is designed to take full advantage of the compact, space-saving features and high-capacity of Bantam's Quill Bearing. Built by Sterling Motors Corp. for use on heavy-duty Sterling trucks, it illustrates another application for this low cost anti-friction bearing. Completely self-contained, the Quill Bearing is admirably adapted to production-line assembly methods. For details on this unusual bearing, write for Bulletin R-104.



FOR HEAVY-DUTY WELL DRILLING, Pennington Signaling Core Barrel's 12¾" oil-bath rotary offers outstanding advantages in capacity and economy. Photo shows Bantam Ball Thrust Bearings and drive gears which give this rotary a capacity of 70 tons at 100 RPM, permit it to be operated continuously at 600 RPM when drilling. "Bantam Bearings are precision-made," says Mr. Harry Pennington, "and we could ask for nothing better than what you furnish. Our products are also precision-made to take advantage of Bantam's accuracy."

4000-TON FORMING PRESS built by Baldwin-Southwark is powered by two Oilgear Two-way Variable Displacement Pumps with a combined displacement of 143 gallons of oil per minute at pressures up to 3,000 pounds per square inch. Each pump rotor turns on large Bantam Radial Roller Bearings—7.0866" I.D. for front rotor bearings, 9.0551" I.D. for rear rotor bearings.

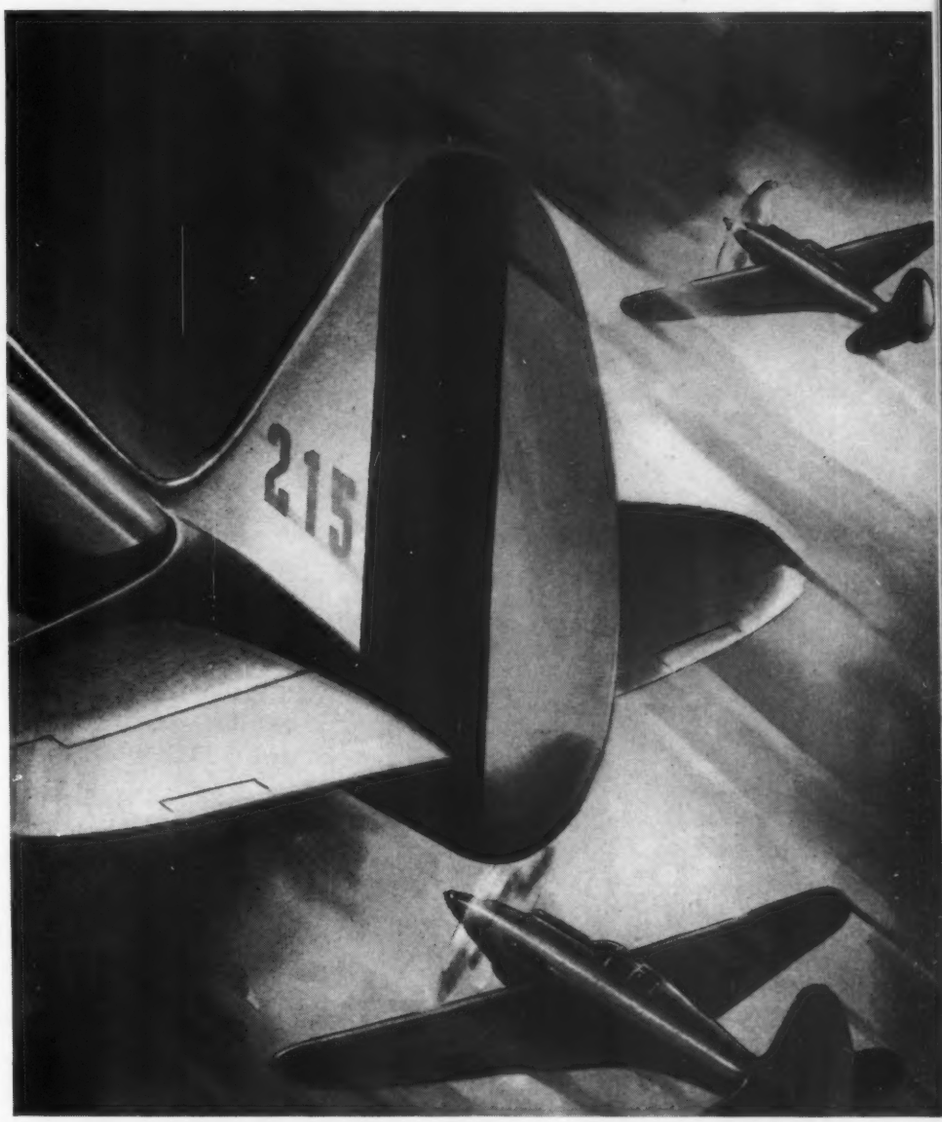
BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

Serving Trays and Aircraft Stabilizers

....what have they in common?



BAKELITE Phenolic Resin wood adhesives, which for several years have demonstrated their strength and durability in the bonding of molded plywood for serving trays and a diversity of wood products, are now employed in the production of aircraft stabilizers. For this important, strategic use, they provide the following advantages:

Adaptability to plywood molding technique

Resistance to weathering

Resistance to extremes of temperature

Flame resistance

Toughness to withstand vibration stresses and wind impact

Resistance to mold

AIRCRAFT MANUFACTURERS, seeking a superior wood glue that possessed the necessary properties required for plywood aircraft stabilizers, found the answer in BAKELITE Liquid Phenolic Resin wood adhesives. These synthetic resin glues have been employed successfully for several years in hot press, plywood bonding, chiefly in the manufacture of furniture, decorative paneling, serving trays, and other consumer goods.

The properties that made these adhesives ideal for peacetime production, immediately were put to work for more vital and strategic uses of which the aircraft stabilizer is but one example. Because the wood adhesives were available and manufacturing technique already established, valuable time was saved in converting materials and equipment to essential purposes.

Bakelite Corporation has developed many types of BAKELITE Phenolic and Urea wood adhesives, each possessing its own unique combination of advantages.

For further information on these synthetic resin glues, write Department 33.

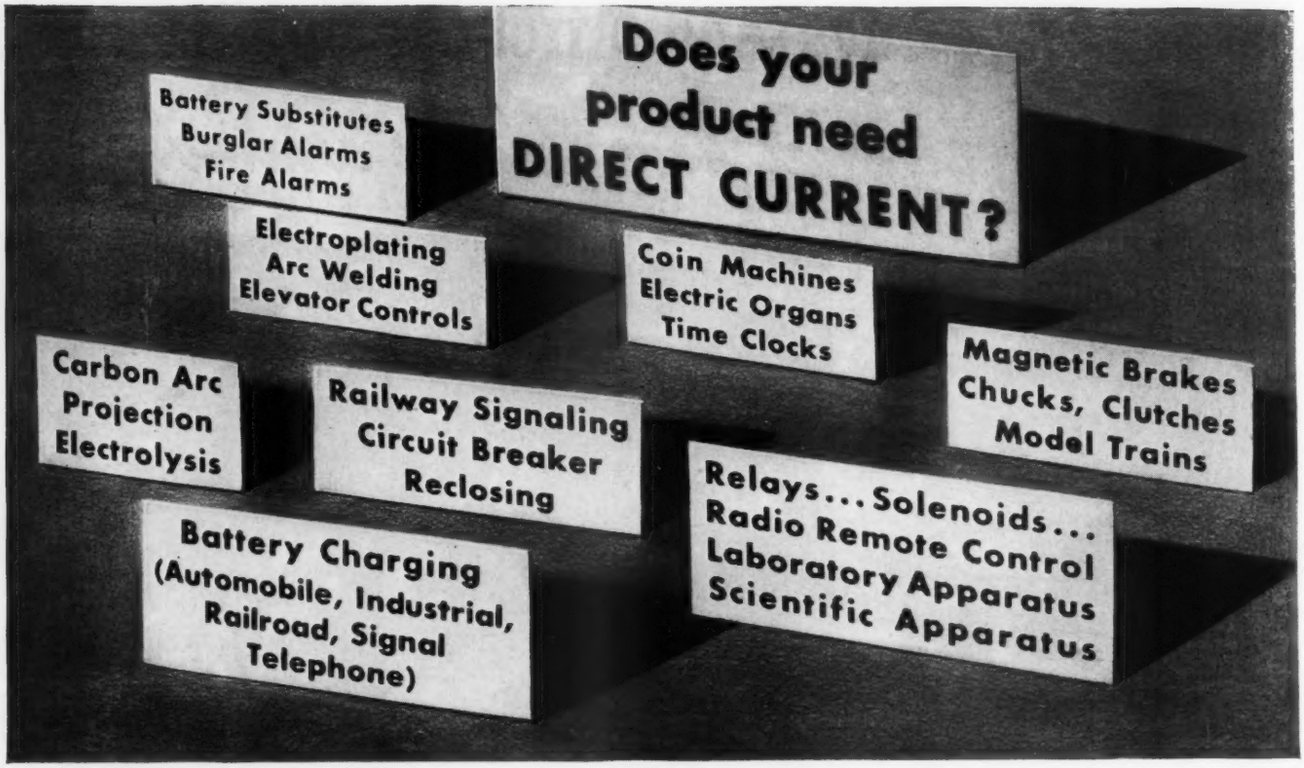
BAKELITE CORPORATION, 30 EAST 42ND ST., NEW YORK
Unit of Union Carbide and Carbon Corporation

UCC

BAKELITE
TRADE MARKS

The word "Bakelite" and the identifying products Symbol are registered trade-marks of Bakelite Corporation

PLASTICS HEADQUARTERS



Many times it is possible to simplify mechanisms, cut costs and improve reliability of operation by the use of direct current for control or power circuits, or electrically operated equipment.

And many D.C. power applications may be made more reliable, more efficient and more compact if available A.C. power is converted to D.C.

The function of Mallory Rectifiers is to convert A.C. to D.C. They are noiseless, long-lived, compact—furnished in standard capacities or built to your particular requirements.

If your product requires A.C. rectification, write for the new Mallory booklet. It contains a wealth of information on the selection and application of the proper rectifier for your need.

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA *Cable Address*—PELMALLO

A few of the basic *individual* characteristics of both Cast Iron and Steel are listed. ***MEEHANITE*** castings offer you, through composition and structural control, a *combination* of these properties, permitting simplification of design and demanding no sacrifice of one in order to be assured of another.

Write for the property Wheel Chart. It tells you what you can get with Meehanite.

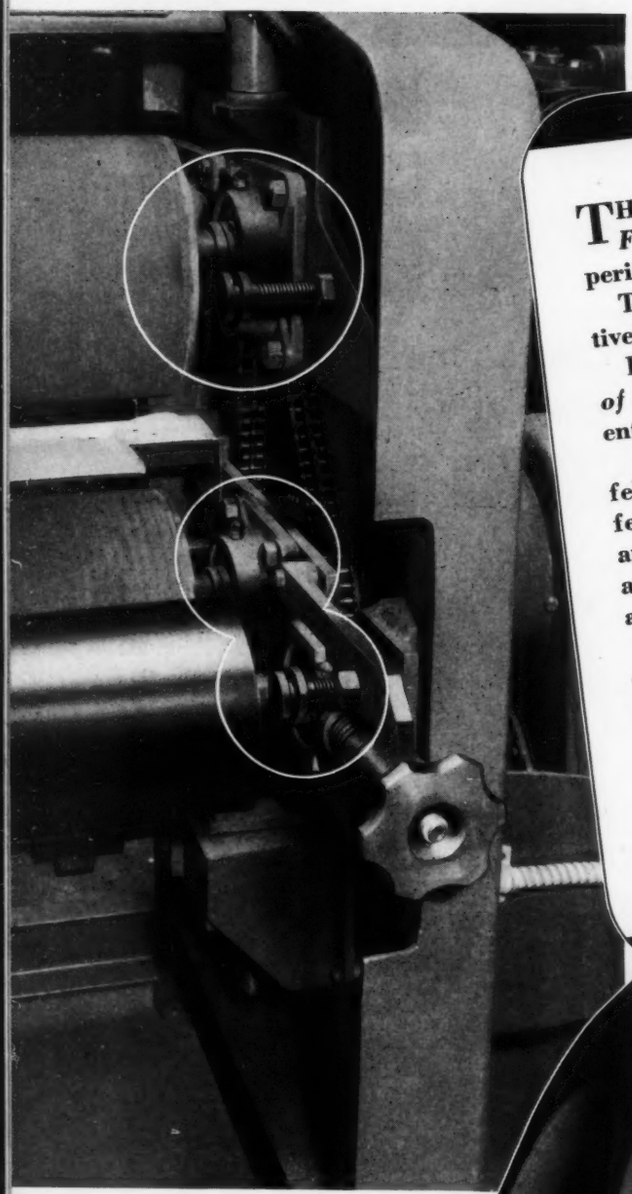
When you specify ***MEEHANITE*** you are not specifying just another cast iron but a *special* material—tested step by step and manufactured with your needs in mind. It is able to supply you with the right combination of engineering properties for your job.

Meehanite Research Institute · 311 ROSS STREET · PITTSBURGH, PA.

Take Your Casting Problems to a Meehanite Foundry!

Ansonia, Conn.	Farrel-Birmingham Co., Inc.
Bethayres, Pa.	H. W. Butterworth & Sons Co.
Bridgewater, Mass.	The Henry Perkins Co.
Buffalo, N. Y.	Pohlman Foundry Co., Inc.
Charleston, W. Va.	Kanawha Manufacturing Co.
Chattanooga, Tenn.	Ross-Meehan Foundries
Chicago, Ill.	Greenlee Foundry Company
Cincinnati, Ohio	Cincinnati Grinders Incorporated
Cincinnati, Ohio	The Cincinnati Milling Machine Co.
Cleveland, Ohio	Fulton Foundry & Machine Co.
Denver, Colo.	The Stearns-Roger Mfg. Co.
Detroit, Mich.	Atlas Foundry Co.
Flint, Mich.	General Foundry & Mfg. Company
Hamilton, Ohio	Hamilton Foundry & Machine Co.
Irvington, N. J.	Barnett Foundry & Machine Co.
Los Angeles, Calif.	Kinney Iron Works
Milwaukee, Wis.	Koehring Company
Mt. Vernon, Ohio, Grove City, Pa.	Cooper-Bessemer Corporation
New York, N. Y.	The American Brake Shoe & Foundry Co.
Oakland, Calif.	Vulcan Foundry Company
Orillia, Canada	E. Long, Ltd.
Philadelphia, Pa.	Florence Pipe Foundry & Machine Co., (R. D. Wood Company, Selling Agents)
Phillipsburg, N. J.	Warren Foundry & Pipe Corp.
Pittsburgh, Pa.	Meehanite Metal Corporation
Pittsburgh, Pa.	Rosedale Foundry & Machine Co.
Rochester, N. Y.	American Laundry Machinery Co.
St. Louis, Mo.	Banner Iron Works
St. Paul, Minn.	Valley Iron Works
London, Eng.	The International Meehanite Metal Co., Ltd.
Waterloo, N. S. W.	Australian Meehanite Metal Co., Ltd.
Johannesburg, South Africa,	Meehanite Metal Co. (S.A.) (Pty.) Ltd.

Why SEALMASTERS Operate at Low Cost



Almost any machine can use SEALMASTERS to economical advantage. Here is a ply wood glue coating machine equipped with both SEALMASTER Flange and Take-Up Units.

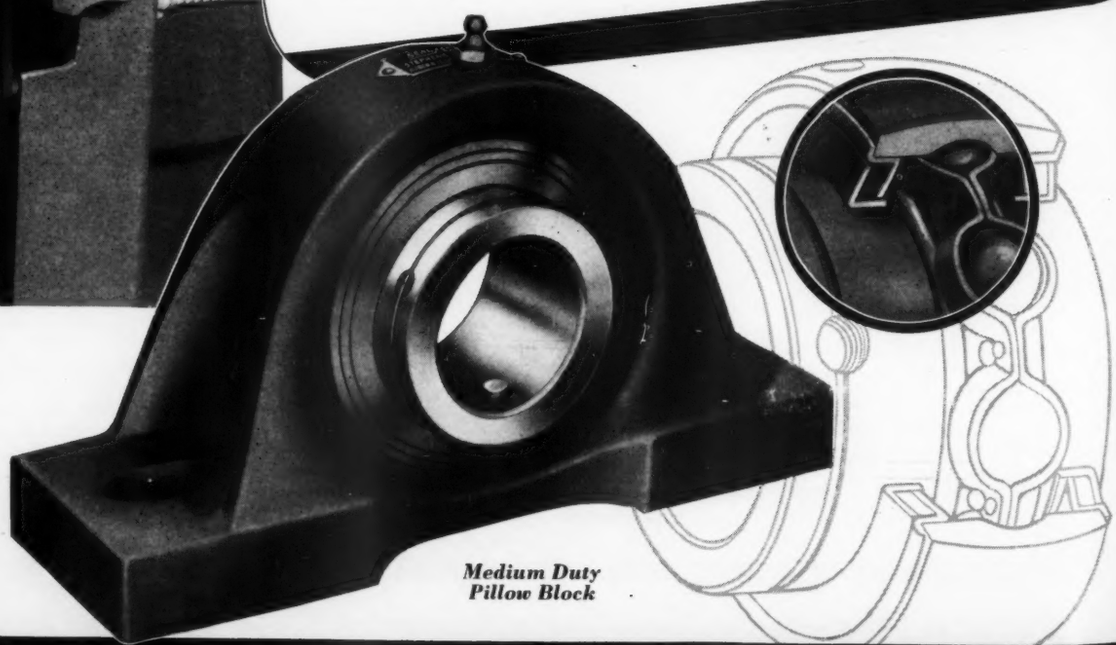
THERE are two prime requisites to low cost bearing operation. *First*, bearing must retain proper amount of lubricant over long periods. *Second*, bearing must keep out dirt and dust particles. The advanced *patented seal* in SEALMASTERS does most effectively this important two-fold job.

In addition, you secure *self-alignment without possible distortion of the seal*, for seal is built integral with bearing proper, independent of housing.

Steel flingers, attached to inner race ring, have special sealing felts impounded on inner faces; these felts, rotating in groove of inner seal, are assembled with close running clearances, but without interference, and are *free-running*.

For the complete story on low cost operation of SEALMASTERS, *write for your free copy of Data Book 840.*

Bearing Division
Stephens-Adamson Mfg. Co.
9 Ridgeway Ave. Aurora, Illinois
Western Plant: Los Angeles, Calf. — Canadian Plant: Belleville, Ontario



Medium Duty Pillow Block

Engineering Offices — BOSTON • BUFFALO • CHICAGO • DETROIT • LOS ANGELES • NEW YORK
PITTSBURGH • PORTLAND • SALT LAKE CITY • SAN FRANCISCO • MONTREAL • TORONTO

A SUBSTITUTE FOR COPPER

Silver laminated to unrestricted base metals in wire, flatstock or fabricated parts makes good conductive material-strong, dependable and capable of carrying current without loss or deterioration. So do low cost silver alloys—also available in all forms.

A NON-CORROSIVE METAL

Silver laminated metals—in flat stock, coils or tubing—are economical metals to use under corrosive conditions. The solid silver surface provides the protection from corrosion. And the base metal—permanently bonded to the silver—adds strength and rigidity.

IT'S ECONOMICAL TO USE

Due to General Plate's precision manufacturing processes, laminated silver metals are produced at a cost which makes them practical, when compared with solid precision metals, for almost all applications—regardless of size, shape, type or quantity required.

Silver Laminated Metals may Solve Your Substitute Problem

See if it is possible for you to make good use of the many types of laminated metals that General Plate engineers are producing for equipment manufacturers. For many years General Plate have specialized in developing laminated combinations of metals to meet unusual requirements economically. There is a possibility that General Plate can pull you out of your metal hole. If you have any requirements simply write, specifying them. Your request will be attended to promptly and confidentially.

General Plate Division *of Metals & Controls Corp.*

Metals and Controls Corporation Divisions manufacture the following products: Laminated & solid precious metals, electrical contacts—Solid and rolled plated precious metals in all forms Truflex Thermostatic Bimetals.

34 FOREST STREET · · · ATTLEBORO, MASSACHUSETTS

DEMOLITION BOMBS

made of

N-A-X

High Tensile

In applications such as demolition bombs, N-A-X HIGH TENSILE is ideal, for it meets the exacting specifications set up for this important defense material. This superior low alloy steel possesses outstanding impact properties—an item of particular importance in applications of this sort.

N-A-X HIGH TENSILE has other important properties, too, that permit the fabricator to form these bombs with speed and ease. This superior low alloy steel works well in all phases of manufacture, and its outstanding ductility and forging properties combined with excellent welding characteristics make for low-cost fabrication.

In hundreds of exacting applications, N-A-X HIGH TENSILE has proved without question that it is a really superior low alloy steel. In parts or products that must operate in all kinds of weather, over undeveloped terrain, the impact and fatigue resistance of N-A-X HIGH TENSILE has given equipment longer life with lower upkeep cost.

Great Lakes engineers, who have experience covering N-A-X HIGH TENSILE in all types of applications, will be glad to assist you in the use of this outstanding low alloy steel. Telephone, wire or write for one of these engineers today. No cost or obligation.

LIST OF PRODUCTS

Hot Rolled Strip (down to 1 inch wide) . . . Hot Rolled Strip Sheets (up to 91 inches wide) . . . Spring Steel (carbon and alloy) . . . Merchant Bars . . . Forging Bars . . . Automobile Bumper Sections . . . Bar Mill Sections . . . N-A-X HIGH TENSILE Bars, Shapes, Sheets, Billets . . . Sheet Bars . . . Hot and Cold Rolled Sheets . . . Michigan Metal for Vitreous Enameling . . . Deep Drawing Quality (in all grades, widths up to 91 inches) . . . Stran-Steel Metal Framing for Residential and Commercial Construction.

GREAT LAKES STEEL CORPORATION—DETROIT, MICHIGAN

Sales Offices in Principal Cities

division of NATIONAL STEEL CORPORATION

Executive Offices, Pittsburgh, Pa.

PRE-ASSEMBLED *Fastener Units!*

LOCK WASHER IS FREE TO ROTATE . . . AND CAN'T DROP OFF!

Now available through the following leading Fastening Manufacturers

AMERICAN SCREW COMPANY
PROVIDENCE, RHODE ISLAND

CHANDLER PRODUCTS CORPORATION
CLEVELAND, OHIO

CONTINENTAL SCREW COMPANY
NEW BEDFORD, MASSACHUSETTS

RELIANCE SPRING WASHER DIVISION
EATON MANUFACTURING COMPANY
MASSILLON, OHIO

THE LAMSON & SESSIONS CO.
CLEVELAND, OHIO

THE NATIONAL SCREW & MFG. CO.
CLEVELAND, OHIO

PHEOLL MANUFACTURING CO.
CHICAGO, ILLINOIS

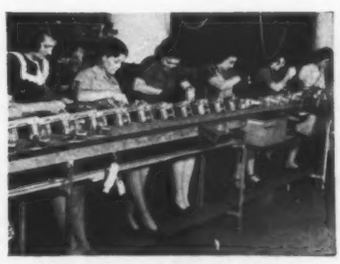
SCOVILL MANUFACTURING COMPANY
WATERBURY, CONNECTICUT

SHAKEPROOF Inc.
CHICAGO, ILLINOIS

THE STEEL COMPANY OF CANADA, LTD.
HAMILTON, ONTARIO, CANADA

No Time Wasted Doing This!

No Dropped Lock Washers!



Faster—Smoother Assembly!

LICENSOR

ILLINOIS TOOL WORKS.....Chicago

"OUT THE WINDOW" WITH COMPLAINTS

. . . and the man who keeps them out!

ONE WAY to keep customers happy is to help them eliminate complaints. How Du Pont "lends a hand" is shown in a recent unsolicited letter from a manufacturer of metal casement windows:

"Two years ago we put in our new bonderizing plant and filled the 1600-gallon tank with the paint formula recommended by our Du Pont man.

"Since then we have received only three trivial complaints, so you see the paint has been entirely satisfactory.

"Also please accept our thanks for the excellent technical service of the Du Pont man throughout these two years."

The Du Pont man is able to help *keep out* complaints because his service represents the total experience of skilled specialists—research chemists, laboratory technicians, production men, service engineers, field representatives—all with the very finest of facilities for developing, making and applying better finishes.

It is this *teamwork* coupled with years of experience which gives Du Pont that extra "know how." That's why so many manufacturers have turned to Du Pont for assistance in finishing processes. They know their problems are in the best possible hands . . . and that, as new finishing problems come up, Du Pont will tackle them and come out with the right answer.

Listen to "Cavalcade of America" every Mon. eve. over coast-to-coast NBC Red Net.

"New Frontiers Through Chemistry"

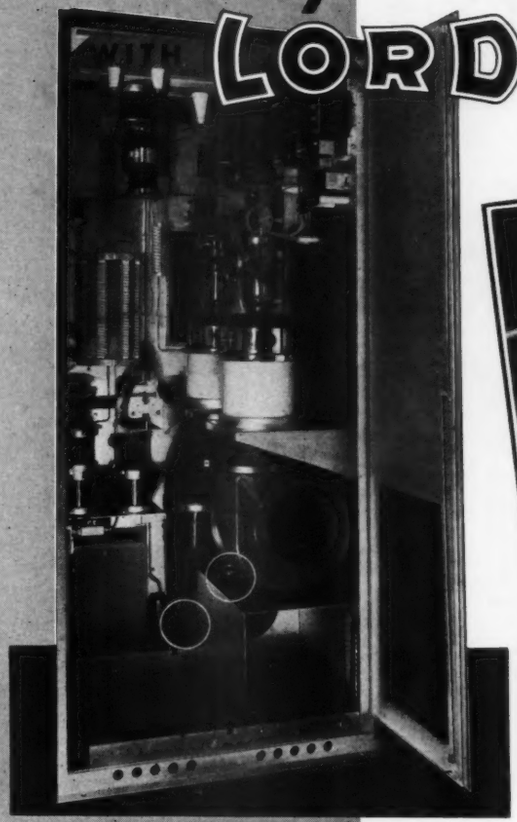
. . . yours for the asking!

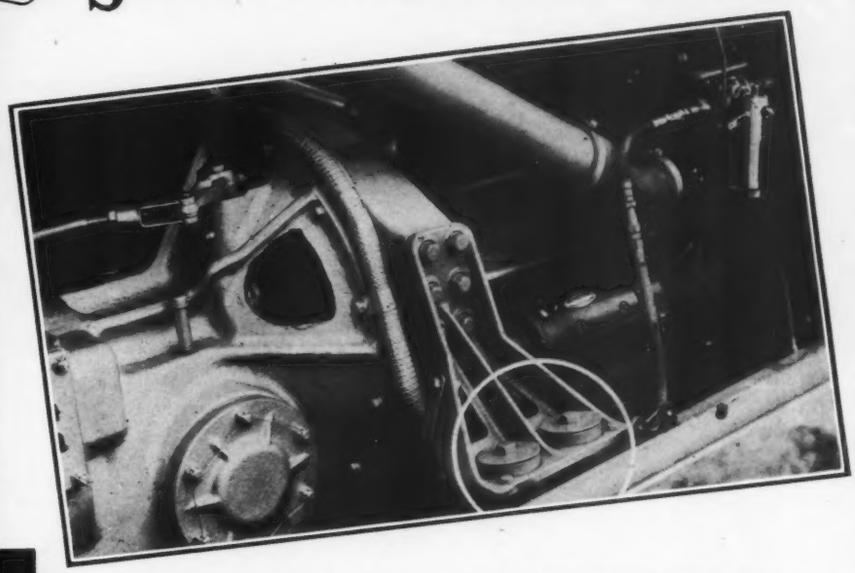
▶ This interesting new book, prepared by Du Pont, describes many of chemical science's discoveries; the research, the testing, the inside story of many of chemistry's sensational triumphs. For your FREE copy just write to: E. I. du Pont de Nemours & Co. (Inc.), 7148-D, Du Pont Bldg., Wilmington, Delaware.

E. I. DU PONT DE NEMOURS & CO. (INC.), FINISHES DIVISION, WILMINGTON, DEL. DU PONT REG. U.S. PAT. OFF.

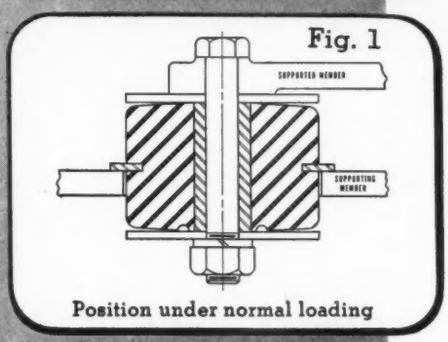
Two-Way Protection

WITH LORD VERTICAL SNUBBING MOUNTINGS

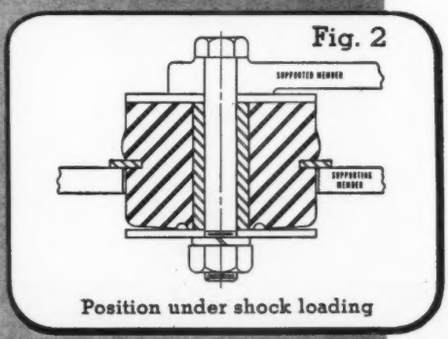




Above: Lord V.S. Mountings protect this Twin Coach bus engine against road shock and isolate the body from engine vibration. Left: In this radio installation Lord V.S. Mountings isolate the normal vibratory forces caused by the blowers and protect it against shock due to starting loads and possible operation at resonance.



Position under normal loading



Position under shock loading

❶ *Protect equipment against shock*
❷ *Isolate smaller vibratory forces*

MANY types of mechanical equipment are subjected to sudden, heavy shock loads as well as normal vibratory forces. It is possible to isolate these two types of disturbances by the use of Lord Vertical Snubbing (V.S.) Bonded Rubber Mountings, illustrated below. These mountings will support loads from a few ounces up to 1150 pounds.

The design for this two-way protection is shown in the V.S. Plate Form Mounting cross-sections at the left. Figure 1 shows the mounting supporting its rated load and it is operating freely in sheer, isolating normal vibration. Figure 2 illustrates the action at the moment of shock. The metal washer has contacted the rubber snubbing shoulder and movement of the suspended member has been arrested. The reverse of shock, or rebound, will then occur and is arrested in a similar manner as shock, but in the opposite direction. Stability of the mounted assembly is characteristic of all Lord Mounting installations.

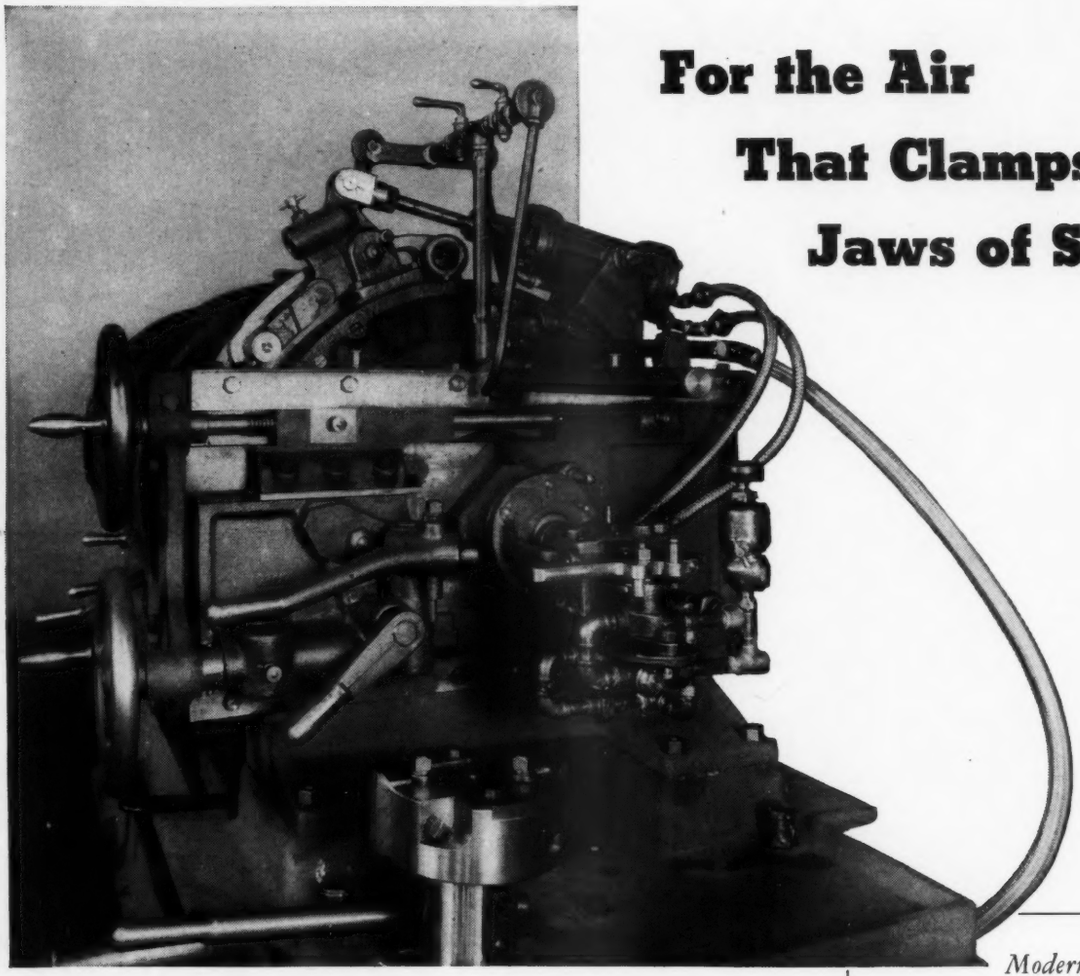
The vibration engineering experience of Lord Engineers, gained in practically every field, is available without obligation.

LORD MANUFACTURING COMPANY . . . ERIE, PA.

245 E. OLIVE AVE., BURBANK, CAL. 280 MADISON AVE., NEW YORK 844 N. RUSH ST., CHICAGO

IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION

For the Air That Clamps These Jaws of Steel . . .



Modern pipe threading and cutting-off machine manufactured by the Landis Machine Co., Waynesboro, Pa.

THE JOB of the modern threading and cutting-off machine shown here is to "put the bite" on a daily diet of cold metal pipe. So, naturally, every part of it has to be plenty tough. And that's one reason why American Flexible Metal Hose was chosen for a *double* assignment on the machine. Parallel lengths of American Flexible Steel Tubing carry air under pressure to open and close the die heads. And American Type BD20 steel carries coolant to the cutting surface.

In both cases, the "garden hose" flexibility of American Metal Hose was an important reason for its choice. The pressure lines must take up a movement of about two inches every time the die heads open and close . . . while the coolant line must be free to move with the carriage of the machine as it operates.

At the same time, the coolant line, carrying a cutting oil, and the pressure lines, exposed to oil splash, had to be impervious to the deteriorating effects of the oil. Because its all-metal construction rules out "oil rot," here again American Flexible Metal Hose more than measures up to the mark.

Defense has drafted American Metal Hose and Tubing

. . . for lines on modern machine tools and for flexible connectors on all types of machinery now working overtime for national defense. Despite expanding plant facilities, it will not be possible for us to meet *all* civilian requirements. But *American* will continue to serve in old duties—and when peacetime requirements are again "first", *American* will still lead in the flexible connector field.

Write for Bulletin No. 40 illustrated below. It contains complete information on "American Seamless"—its properties, available forms, typical uses and methods of application. 41270

American Metal Hose

ANACONDA
from mine to consumer

American Metal Hose Branch of The American Brass Company
General Offices: Waterbury, Conn. • *Subsidiary of Anaconda Copper Mining Co.*
In Canada: Anaconda American Brass Ltd., New Toronto, Ontario

Another nationally famous user of

MASTER MOTORS

To maintain their position of leadership SCHENLEY DISTILLERS CORPORATION uses the best of materials and the finest of processing equipment. Schenley engineers find that their plant equipment is improved, made more compact, lower in cost, more convenient, more safe by using Master motors that meet the requirements exactly of each individual application.

You too may secure these advantages. When you need motors for your plant or your product, investigate MASTER'S unusual ability to serve you promptly and economically with motors that really fit your needs.

THE MASTER ELECTRIC COMPANY • DAYTON, OHIO

MASTER

Stradivarius would approve...

THIS BIG ASSIST FROM DU PONT "LUCITE"!

DEFT old Stradivarius (1644-1737)—greatest of all violin craftsmen—would have welcomed "Lucite" methyl methacrylate resin. For chin rests made of "Lucite" overcome the objections of fiddlers to rubber, ebony and other woods.

In crystal-clear, black, opaque, transparent amber and tortoise shell, the new Kleerest, molded from "Lucite," is winning bravos. It is sanitary, odorless and light in weight. Warm to the touch and smooth, it has the desirable property of clinging to the chin, thus giving a violinist a surer grip on his instrument.

Overcoming the handicaps of other materials is often accomplished by the additional properties of "Lucite." It is strong and tough . . . resists shattering and chipping . . . holds metal inserts securely, as in the chin rest . . . retains its shape after molding. "Lucite" is light in weight and sparklingly clear. And it resists outdoor exposure and the attacks of many chemicals.

Think of the big things these properties of "Lucite" can do for your product. Now is the time to investigate "Lucite" and other Du Pont plastics for future applications. Experimental samples and Du Pont Technical service are at your disposal. E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Arlington, New Jersey.

"Lucite" is Reg. U. S. Pat. Off.

DU PONT
REG. U. S. PAT. OFF.

PLASTICS

A STATEMENT BY DU PONT ABOUT PLASTICS

• Defense requirements and unusual commercial demands exceed the supply of some Du Pont plastics. National Defense orders will get preferred attention, of course. But Du Pont is bending every effort to satisfy commercial and replacement needs. Shortages of equipment and raw materials necessarily limit this effort.

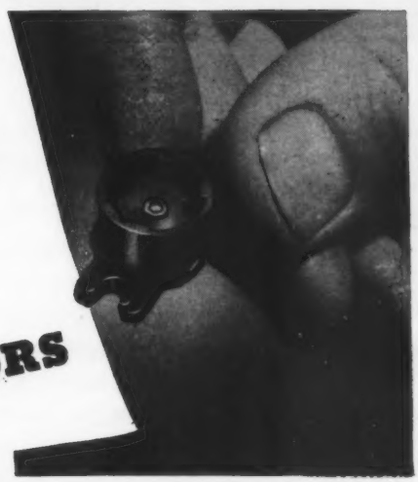
Du Pont is also instituting a broad research and development program. We believe that from this program will come improvements in existing plastics and the creation of entirely new types with new and valuable properties. The results of this research will be reported to you as they develop.

Stories of Du Pont plastics applications and developments will continue to appear in advertisements. We hope you will find it helpful to apply this information to your present and future needs. Meanwhile, Du Pont technicians are ready to devote their knowledge and facilities to your product problems.

Meet Machine-Tool Electrical Standards with

KLIXON

TRANSFORMER PROTECTORS



A Sure, Simple Overheat Protector for Transformers, Large or Small

Small and compact, the foolproof thermostatic-disc-operated Klixon Protector is easily and economically built into the transformer by the manufacturer. Sizes are available for practically all ratings—covering general purpose industrial, signaling, lighting, toy, control and other types of transformers. Both manual and automatic reset types of protectors are available.

Write for full information

According to the new specifications of the National Machine Tool Builders' Association, protective devices are *musts* for machine-tool transformers. And the simplest, most satisfactory answer to this requirement is a Klixon *snap-acting* Protector built right into each transformer. Equipped with a Klixon Protector, a transformer is completely protected from any and all types of overloads, including shorts—and the transformer can be used right up to its maximum output with safety.

Klixon Protectors are practical. They are easily built right into any transformer. And the cost of this protection is *low*. Write for complete information.

KLIXON
TRADE MARK REG. U.S. PAT. OFF.
Over-Heat Protectors

SPENCER THERMOSTAT COMPANY • 912 FOREST STREET, ATTLEBORO, MASSACHUSETTS

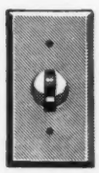
Westinghouse

...ne motor ...places six

Completely self-protected

PROBLEM—Unit heater manufacturers were using six different motors to meet requirements for constant, two-speed, and multi-speed operation on both 115 and 230-volt circuits. To reduce stocking, to speed production, to open new markets, they wanted simplification.

SOLUTION—Westinghouse unit heater specialists designed a dual-voltage motor suitable for all three operating conditions. Now, one motor takes the place of six and provides, in addition, other special advantages—"no bump" bearings, quiet operation, extra flexibility of mounting.



This ordinary on-off switch gives single speed on either 115 or 230 volts.

This inexpensive switch gives two speeds on either 115 or 230 volts, without transformer or change in motor.

This low-cost self-contained speed controller gives multi-speed operation on either 115 or 230 volts without change in motor.

Available from 1/20 to ¾ hp for band or resilient mounting, floor or ceiling, this special motor is used by more unit heater manufacturers than any other make.

PROBLEM—Most householders lack mechanical knowledge. Therefore, stokers require motors completely self-protected against the application's extreme hazards—immune to burnout from clogged feeds, excessive temperatures, improper ventilation and overloads—self-starting after low voltage—dust-free.

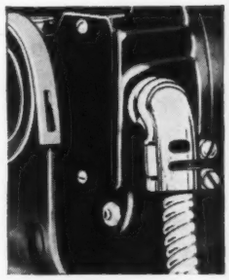
SOLUTION—Westinghouse stoker specialists designed this capacitor-start, Thermoguard-protected, totally-enclosed motor to completely eliminate stoker drive worries. Thermoguard interrupts circuit the instant abnormal load, current, or heat conditions arise, automatically restores circuit when safe temperature is reached—may be used to operate bell alarm, if desired.

CLICK! IT'S OFF!

Simple, Bi-metal, Thermoguard disc opens circuit with rifle-bullet speed when motor temperature reaches danger point.

CLICK! IT'S ON!

With return of safe conditions, Thermoguard restarts motor automatically.



ARRANGED FOR HANDY BX CONNECTOR

Conduit box is fitted with a removable plug permitting use of standard BX conduit for wiring motor.

Available in sizes from ⅛ to ¾ hp at all standard speeds for either 110 or 220 volts (dual voltage above ¼ hp) with rigid or resilient mounting.

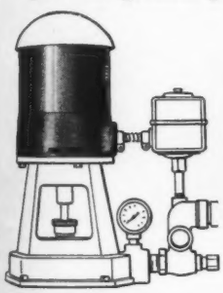
Westinghouse

helps industry move ahead!

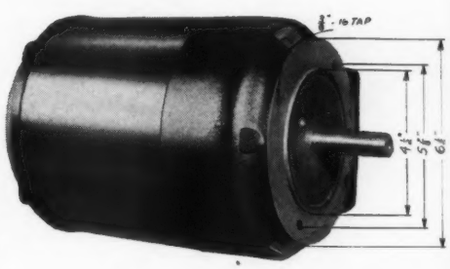
Capacitor and cable connection mounted inside base

PROBLEM—Nothing was basically wrong with flange-mounted jet pump motors—but adoption of standard mounting dimensions by NEMA necessitated minor design changes. To Westinghouse specialists the situation presented an opportunity to streamline the motors to the application.

SOLUTION—Using the new NEMA dimensions as a base—Westinghouse specialists built up an entirely new, advanced design with capacitor and conduit box built-in to the lower bracket to improve appearance, make connections shorter and more convenient, and provide greater protection to capacitor.



Standardized Flange Mounting Motor applied to jet pump. Capacitor now mounted inside *lower* bracket for better appearance and protection. Lower bracket location of conduit box more convenient, better looking, and shortens conduit required.



Both frame 145 and frame 186 now made in ball-bearing construction, all types and ratings, for flange mounting with these new NEMA dimensions.

Available in standard flange mounting and ball-bearing construction for all ratings in the Westinghouse 145 and 186 series frames, and for rigid foot mounting.

...WITH MOTORS SPECIALLY DEVELOPED FOR SPECIALIZED PRODUCTS

Westinghouse pioneered the small a-c motor fifty years ago, thereby assuming the leader's responsibility for continued development in the small motor field.

And down through the years, as a tenet of that responsibility, Westinghouse has built up a corps of specialized engineers which devotes itself solely to the development of special motors for special industries. For example, many Westinghouse engineers spend their entire working time solving the specific problems of the Unit Heater industry . . . other engineers dedicate their efforts to Stoker manufacturers . . . while others work exclusively on Jet Pump motors.

This engineering organization makes available special motors perfectly adapted for use with your specialized product . . . makes it a desirable move to consult Westinghouse first, relative to your Small Motor needs.

We will consider it a privilege to serve you and to solve for you problems like those listed in the adjoining column—problems which we have solved for manufacturers of Unit Heaters, Stokers and Jet Pumps.

- **For Unit Heater information, write for F-8485.**
- **For Stoker Motor Data, send for F-8489, F-8490.**
- **For Jet Pump Facts, consult your Westinghouse representative.**

J-03138

SMALL MOTORS

Linde Customers

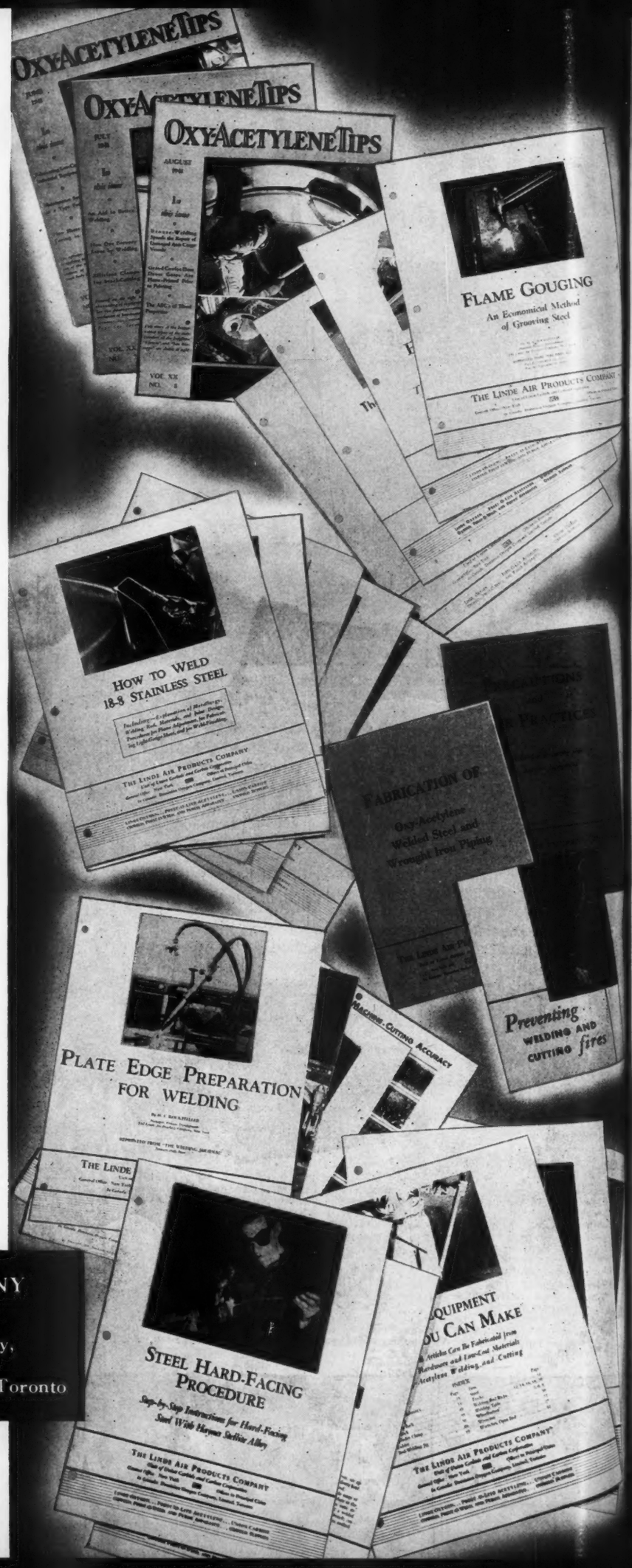
Draw On This Large Library Of Oxy-Acetylene Process Information

THE Linde organization has made available a large library of oxy-acetylene process information on which customers can draw freely. The material in this Linde Library is designed not only to add to the knowledge of welding and cutting operators, but also to suggest to designers, engineers, and production men many ways in which Linde methods can be used to do better or quicker production work where the use of metals is involved. In addition, much of this literature is provided to suggest means of lowering the costs of maintenance work.

The Library consists of handbooks, instruction outlines, reprints of engineering articles, design data, safety folders and even a monthly "how-to-do-it" periodical, OXY-ACETYLENE TIPS. Among the many subjects covered are: oxy-acetylene welding, flame-hardening, flame-priming, flame-gouging, shape-cutting, stack-cutting, and hard-facing.

If you want to know more about how Linde helps its customers use Linde oxygen, Prest-O-Lite acetylene, and Union carbide effectively—get in touch with Linde today.

The words "Linde," "Prest-O-Lite," and "Union" are trademarks of Units of Union Carbide and Carbon Corporation.


OXY-ACETYLENE TIPS
OXY-ACETYLENE TIPS
OXY-ACETYLENE TIPS
FLAME GOUGING
An Economical Method of Grooving Steel
THE LINDE AIR PRODUCTS COMPANY
HOW TO WELD 18-8 STAINLESS STEEL
FABRICATION OF
Oxy-Acetylene Welded Steel and Wrought Iron Piping
Preventing WELDING AND CUTTING fires
PLATE EDGE PREPARATION FOR WELDING
STEEL HARD-FACING PROCEDURE
Step-by-Step Instructions for Hard-Facing Steel With Haynes Stellite Alloy
THE LINDE AIR PRODUCTS COMPANY

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
UCC
New York, Chicago, Birmingham, Kansas City,
San Francisco, and other Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

PARKER PROCESSES are "Pinch-Hitting" for Defense Materials in Many Industries

In the automotive, electrical, architectural and many other industries, Parker Processes are aiding production executives in making successful substitution for strategic protective metals.

If priorities are absorbing your supplies of aluminum, zinc, tin, cadmium or chromium, Parker chemists may be able to show you a satisfactory way to carry on without these critical metals.

Parker Processes are providing adequate finishes in scores of industries. They assure substantial protection, maintain fine appearance and give old products new sales appeal. They provide rust proofing and finish durability on peace-time products or defense materials. Investigate Parkerizing for protection from rust—Bonderizing for finish durability—Parco Lubrizing for wear resistance on friction surfaces. Send for catalogs.

PARKER RUST PROOF COMPANY
2179 E. Milwaukee Avenue • Detroit, Michigan

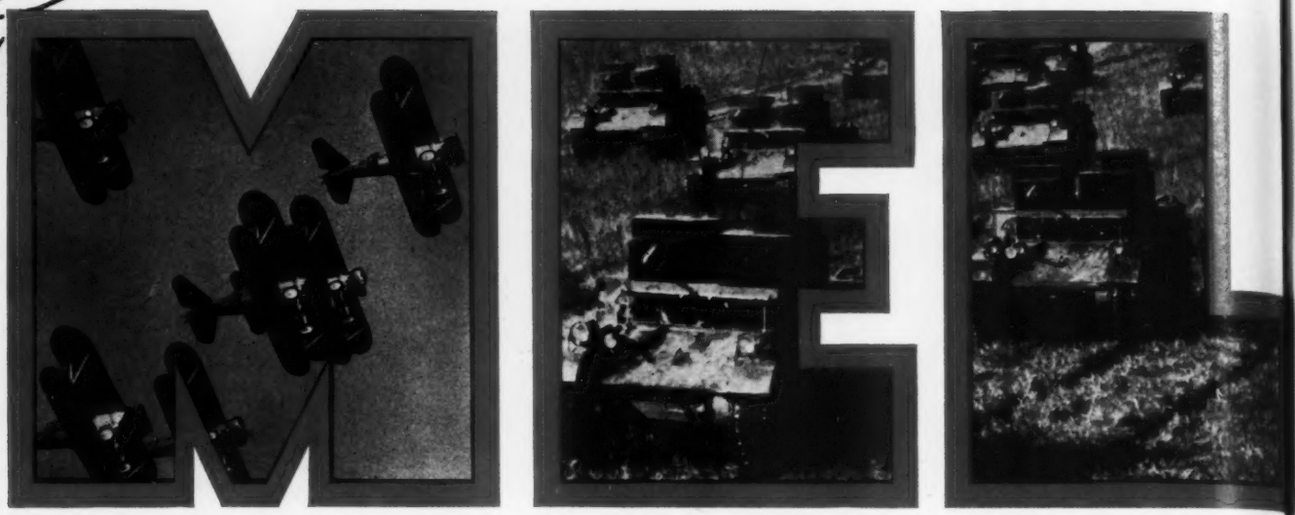
PARKERIZING
A finish and substantial protection from rust on bolts, screws and small mechanical parts.

BONDERIZING
A rust inhibiting paint base that bonds the finish to sheet metal surfaces.

PARCO LUBRIZING
A chemically produced coating for friction surfaces that retains oil and prevents metal to metal contact.

PARKER *Processes* CONQUER RUST
BONDERIZING · PARKERIZING · PARCO LUBRIZING

A NEW PLASTIC FOR DI



FOR PLANES . . . TANKS . . . TRUCKS . . . AN

GIVES 1. HIGHER ARC RESISTANCE; 2. HIGHER DIELECTRIC STRENGTH; AND 3. MAINTAINS THESE PROPERTIES AT ELEVATED TEMPERATURES AND UNDER VARYING HUMIDITY CONDITIONS

For More Efficient Ignition Assemblies and Insulation Parts—To Permit Higher Operating Efficiency, Greater Power Output, Larger Safety Factors, and All-Round Improved Performance

MELMAC† 494, First of a Line of New Industrial Plastics, Combines Physical and Electrical Properties Heretofore Unobtainable In Any Plastic . . .

MELMAC 494 is an achievement of the Stamford Research Laboratories of the American Cyanamid Company, offering these outstanding characteristics to aid in defense production:

1. The highest arc resistance of any thermosetting plastic.
2. The highest dielectric strength at elevated temperature of any thermosetting plastic.
3. Excellent dimensional stability.
4. Extremely low moisture absorption.

These properties are maintained at elevated temperatures and under varying humidity conditions.

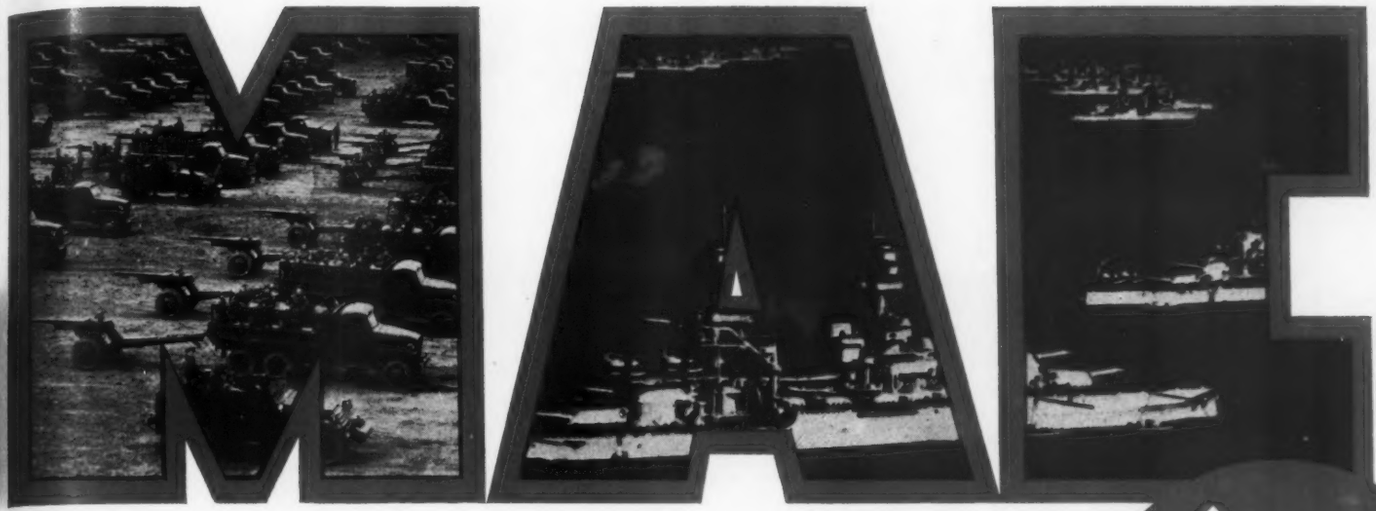
MELMAC 494 is readily adaptable to conventional production methods and equipment for either compression or transfer molding. The regular tools and dies used for making parts with ordinary mineral-filled plastics can be utilized in making *better* parts with MELMAC 494.

MELMAC 494 is now available for defense applications on the basis of priority ratings. Present capacity is being rapidly expanded to meet the increasing demands for this new Cyanamid plastic; an entire *new* large-scale producing plant will be placed in operation early in 1942.

MELMAC 494 may be obtained in "Sample" quantities for experimental purposes. But MELMAC 494 for commercial production of non-defense applications must necessarily be limited for the duration of the present emergency.

American Cyanamid Company · *Plastics Division* · 30 Rockefeller Plaza, New York, N. Y.

DEFENSE...BY CYANAMID!



494

S..ND SHIPS OF THE FLEET!

COMPARE THE PROPERTIES OF MELMAC 494 WITH THOSE OF ANY OTHER PLASTIC MATERIAL YOU HAVE EVER USED!

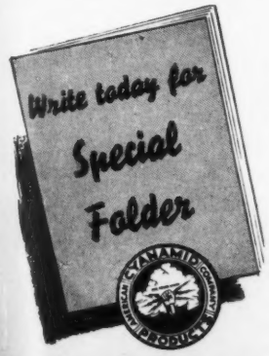
ELECTRICAL PROPERTIES

DIELECTRIC STRENGTH* (Short Time) 60 Cycles Volts/mil at 100° C.	391 (382-403)
Volts/mil at 25° C.	416 (384-424)
After Heating 8 hours at 300° F. Volts/mil at 100° C.	402-466 (2 values)
ARC RESISTANCE* (ASTM) Seconds	145 (142-148)
After Heating 8 hours at 300° F.	157 (146-168)
POWER FACTOR* (60 Cycles)	15.2% (14.9-15.4)
After Heating 12 hours at 270° F.	6.0%
DIELECTRIC CONSTANT* (60 Cycles)	11.7 (10.8-12.3)
After Heating 8 hours at 220° F.	9.7 (9.3-10.5)
LOSS FACTOR* (60 Cycles)	1.80
After Heating 8 hours at 220° F.	1.28

*Tests conducted by A.S.T.M. methods (indicated by *) on test pieces prepared at Stamford Laboratories of American Cyanamid Company. For all electrical tests, a 4" disc, .080" thick, was employed.*

PHYSICAL PROPERTIES

SPECIFIC GRAVITY	1.98
IMPACT STRENGTH* (Izod) per Inch of Notch ft. lb.	0.350
FLEXURAL STRENGTH*	8,000 lb. per sq. in.
MOLDING SHRINKAGE mils/inch	6.8
AGING SHRINKAGE (220° F.), 8 hours on 4" Disc, mils/inch	2.0
WATER ABSORPTION* 48 hours. Water 25° C.	.%10
HEAT RESISTANCE: Not recommended for use where molded parts are subjected to a temperature in excess of 300° F. (148.9° C.)	
COEFFICIENT OF THERMAL EXPANSION 19 x 10^{-6}/° C. (Range −30° C.+60° C.)	
INSERTS: No failure on standard test insert after 7 days at 220° F.	



GET THE FACTS

ABOUT MELMAC 494
"The KEY to BETTER Plastic Products"

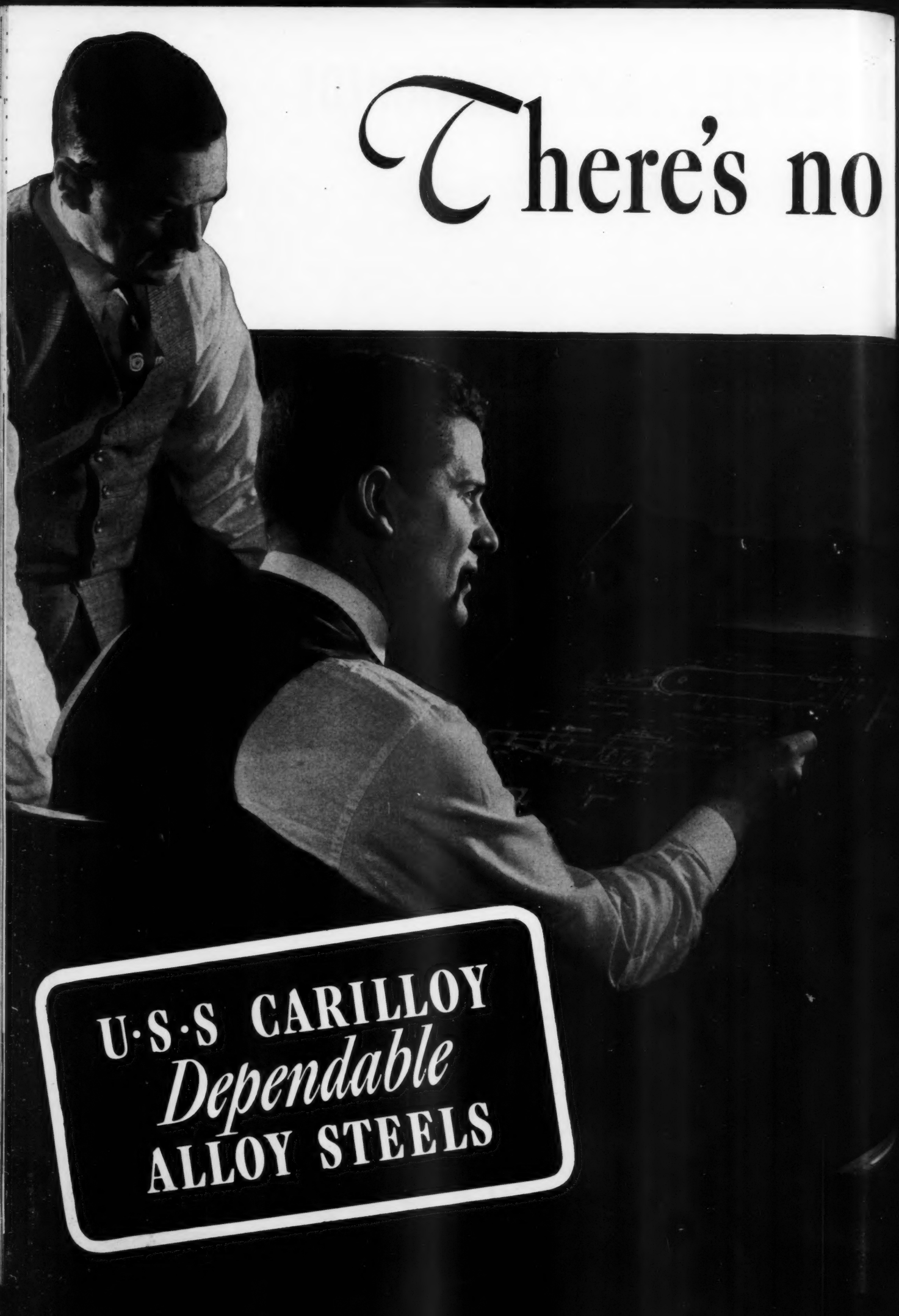
Write today for this new folder listing its properties and molding characteristics.

Melmac†

494

† Reg. U. S. Pat. Off.

A CYANAMID PLASTIC


There's no
U·S·S CARILLOY
Dependable
ALLOY STEELS

o priority on ideas!

Here's a service we can give you right now . . . Expert advice in using your present facilities to best advantage

THE specialized knowledge of our metallurgical contact staff can be of help to you at the present time.

These men are in intimate touch with the rapidly and constantly changing steel picture. They know alloy steels. For years they have worked shoulder to shoulder with men in machine shops, forge plants, and in heat-treating departments and welding shops, digging out the hard facts that make production flow smoothly.

Right now when a new resourcefulness is urgently needed to meet an increasing scarcity of materials, skilled labor and tools, we urge you to draw freely upon this rich reservoir of experience.

If your alloy steel set-up calls for a re-examination and re-orientation, if a revision of your shop practices will expedite production, or if re-design of your product is necessary, the practical advice and guidance these men can bring to your job will help you do it with least waste, trouble and delay.

This service is not new. It was initiated long before the present situation developed. It is seasoned, tried and thoroughly competent. It is offered freely—and it is *immediately* available.

CARNEGIE-ILLINOIS STEEL CORPORATION

Pittsburgh and Chicago

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

USS

UNITED STATES STEEL

For Control of INDUSTRIAL PROCESSING

THE KEY TO CONTROL—Capillary tubing is the all-important link between the point of temperature change and the instrument which indicates or records temperature or pressure.

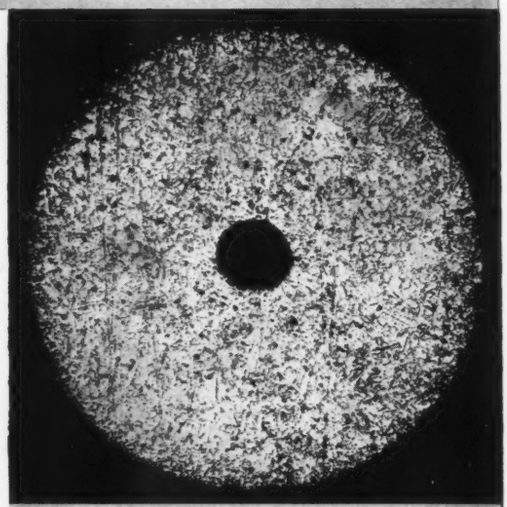
Summerill has not only kept pace with demands for deliveries of both capillary and spring tubing, but in recent months has actually made real strides in quality.

The first requirement for good capillary is the condition of the inside diameter—*the bore*. It must be round, clean and free from radial cracks. Also, it must be produced in long lengths, so that splicing is eliminated for many installations.

Summerill capillary tubing is regularly produced in Stainless, Low Carbon and Copper-Clad Carbon Steel analyses. Other analyses on special order.

Although our present production facilities are devoted to tubing for National Defense, we have a special staff working exclusively on development of new tubing applications. If you too are interested in research on new designs and new products, this staff is available at your call to assist.

Affiliated with Edgar T. Ward's Sons Co.

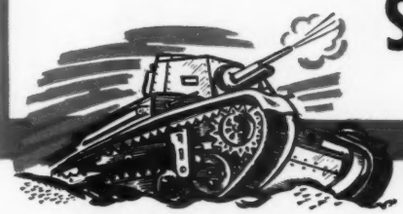


Photomicrograph—or enlarged reproduction—of cross-section to show quality of capillary bore. Size .060″ OD x .007″ ID.

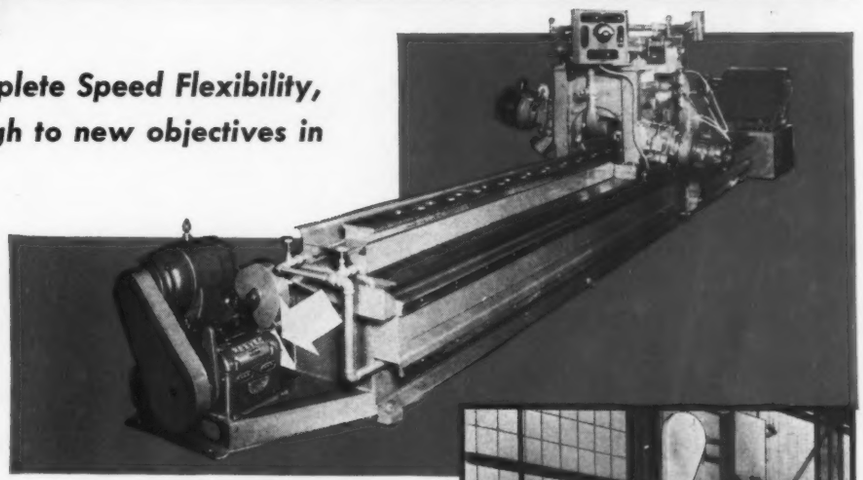
A single length of Stainless Capillary 1830 feet long. Size .060″ OD x .007″ ID.

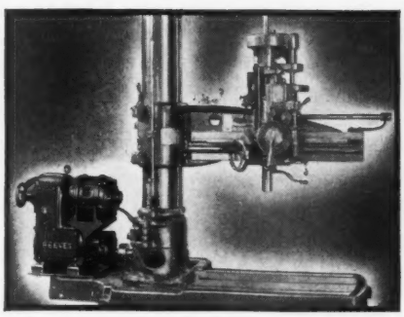
SUMMERILL TUBING COMPANY
Seamless BRIDGEPORT, *Montg. Co.*, PA.

SPEED OF A *Machine* MAY BE AS IMPORTANT AS THE SPEED OF A *Tank!*



● ***When a machine has Complete Speed Flexibility, you can quickly break through to new objectives in defense production . . .***





DRILL PRESS EQUIPPED WITH REEVES MOTODRIVE

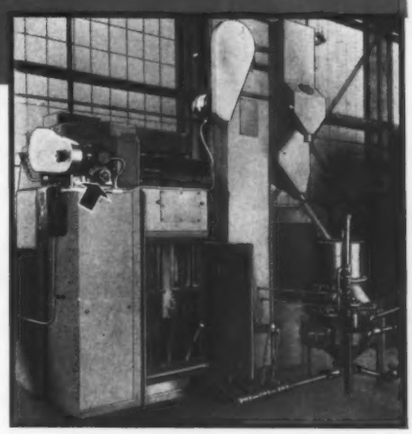
Size of drill, gauge and hardness of metal —*all* influence the speed at which a drill press should be operated, for best results. Presses with inadequate speed control are obviously limited in capacity and variety of work. On the other hand, the radial drill press as shown above, rebuilt by the Louis E. Emerman Co., Chicago, and equipped with a REEVES Vari-Speed Motodrive, is so versatile and flexible it is running continuously in a big armament plant. The "switch over" from one job to another is effected merely by turning a handwheel. The exact speed is so easily attained that REEVES-equipped machines are widely preferred by management and operators.

CUTS TIME FROM 60 HOURS TO 42 MINUTES

This spar milling machine (above) with REEVES Transmission and Electric Remote Control, built by Farnham Manufacturing Co., Buffalo, N. Y., now does in 42 minutes work that used to require 60 hours. On each spar milled, the section varies from end to end. By means of the REEVES Transmission the feed can be adjusted to conform to the various sections and optimum results can be obtained at all points, gradually and without stopping the machine. On high speed milling any jerk in the feed damages the cutters, which run at 3500 r.p.m. with feeds up to 240 inches per minute.

NEW RECORDS SET IN CLEANING SHELLS

Munition shells are blasted with abrasives to clean thoroughly exterior and interior surfaces and, naturally, the speed of the conveyor carrying the shells through the machine must be accurately timed for different shell sizes. This new American Foundry Equipment Shell Blasting Machine is accordingly equipped with a REEVES Vari-Speed Motor Pulley which provides any speed desired and new records for fast processing. No changing of gears, belts, or pulleys is necessary.



NEED HELP? This company maintains a nation-wide staff of factory-trained speed control engineers, located in strategic industrial centers. Their advice and counsel is offered, without obligation, to help speed our defense program. Write, wire or phone REEVES PULLEY CO., Columbus, Indiana.

★ ★ ★

REEVES PULLEY COMPANY

Recognized Leaders in the Specialized Field of Speed Control Engineering

COLUMBUS, INDIANA

REEVES *Accurate Positive* SPEED CONTROL

MACHINING TIME REDUCED 42% ★

★ PRODUCTION INCREASED 72½%

This Gisholt No. 12 Hydraulic Automatic Lathe with Timken Bearing Equipped spindle is machining forged steel (SAE 4150) Diesel engine injector bodies. It does an all-over job in one operation in a floor-to-floor time of 6 minutes. The same work previously necessitated 2 operations requiring a floor-to-floor time of just over 10 minutes. Thus machining time has been cut 42%; production stepped up 72½%. To achieve the same results by the previous method, 2 of the older type machines would have been required.

The increased production made possible by the single Gisholt Lathe not only satisfies assembly line demand, but releases greatly needed floor space and man power for other work.

With manufacturers constantly on the alert to take advantage of the advantages offered by modern Timken Bearing Equipped machinery the success of the National Defense Program is assured—and so is the future of American industry.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

Tapered Roller TIMKEN BEARING EQUIPPED

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

Do You Want to Build A Better Product? Do You Want to Reduce Your Costs?

In this age of manufacturing, industry is constantly on the hunt for better, lighter, stronger, cheaper or more accessible materials.

Steel Castings are meeting these requirements —more of them every day.

In many industries, steel castings are proving to be the most economical and practical way to secure the unquestioned advantages of steel.

STEEL CASTINGS

Bring You These 7 Advantages

1 *Uniform Structure* for strength and shock resistance.

2 *Metal distributed* for strength with minimum weight.

3 *Wide* range of physical properties.

4 *Good Machining qualities* — lower finishing costs, better appearance.

5 *High rigidity,* accurate alignment, minimum deflection, better fit.

6 *Readily weldable* in composite structures.

7 *High fatigue resistance,* longer life, ideal for critically stressed parts.

For steel is an adaptable material. Its applications in industry cover the entire range of manufactured goods, and the machines which make them.

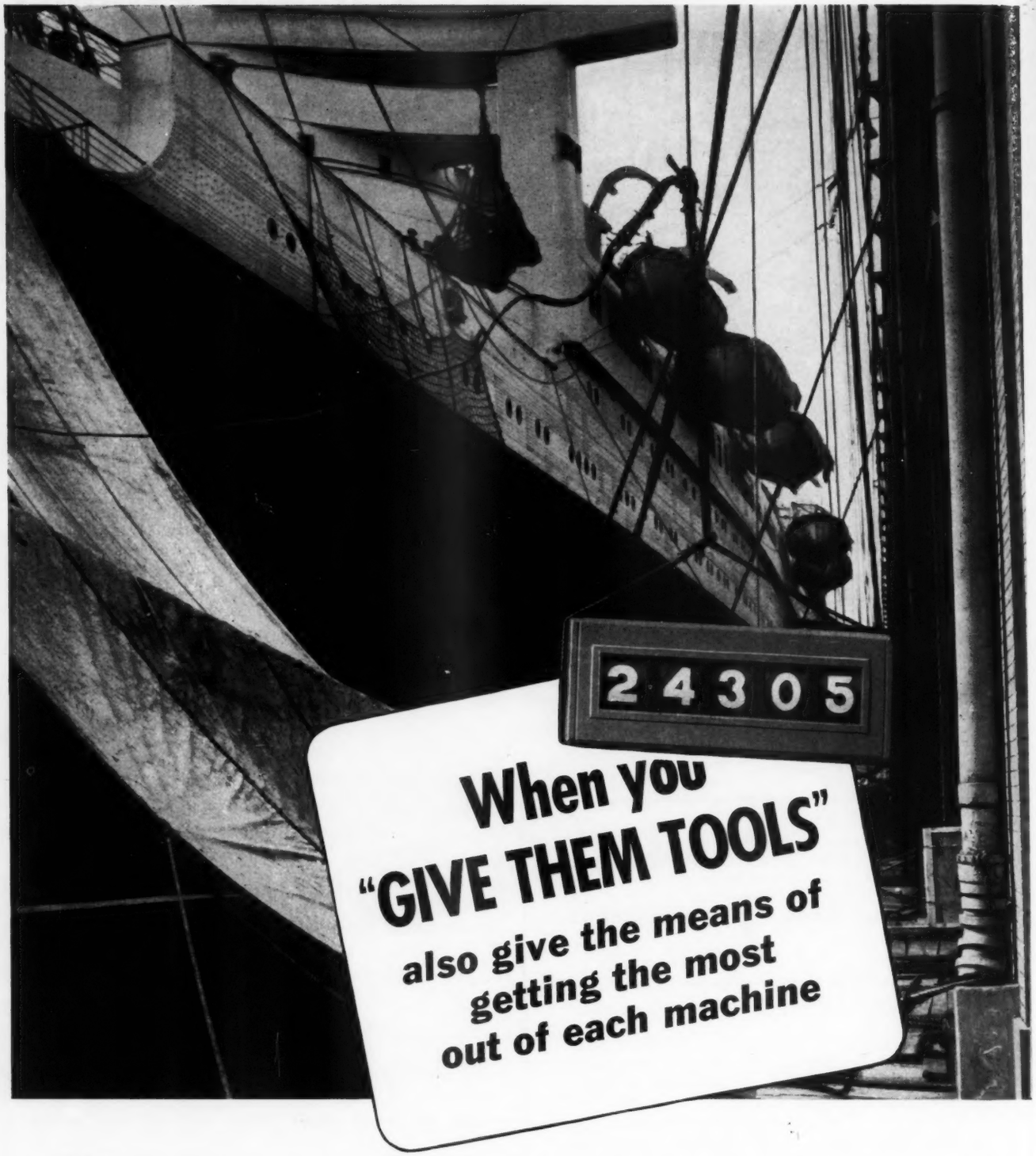
And because of the unusual technical cooperation within the Steel Castings industry, there is a constant free exchange of ideas and experience. Secrets have been shared. Technique has been constantly improved.

As the direct result of this enlightened working together as an industry, new designs and new methods have been perfected, to improve *your* product and reduce *your* costs.

To secure the benefit of the knowledge and experience which is aiding so many manufacturers, you have only to consult your local foundry, or write to Steel Founders' Society, 920 Midland Bldg., Cleveland. Please feel free to call upon our industry—there is no obligation.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS



While you're answering the appeal to "give us tools", give everything that ought to go with them. Into every machine you design and ship for defense production, at home or abroad, build the proper Veeder-Root Counting Device that will help users to get the utmost in quantity and quality of output. And no matter what type of machine you build, there are mechanical and electrical Veeder-Root Counters to provide a running report on production . . . show where adjustments can be made, time saved and quality improved. So be sure to give *complete* tools, equipped to make every stroke of work count to the utmost. And on any such priority work, we are ready to help you *now*.

VEEDER-ROOT
INCORPORATED
Hartford, Connecticut, U. S. A.

OFFICES IN: Boston, Chicago, Cincinnati, Cleveland, Detroit, Greenville, S. C., Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, Montreal, Buenos Aires, Mexico City, London, Paris, Tokio, Shanghai, Melbourne.

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Lebanon Offers 30 Years Experience . . . and More Than 30 Alloys for Steel Castings

ON DECEMBER 11, 1911, the Lebanon Steel Foundry was organized by the two men who still head it—W. H. Worrilow, President and T. S. Quinn, Treasurer. Lebanon's thirty-year study of foundry practice (domestic and European) . . . Lebanon's thirty-year development of alloys for wider and wider ranges of casting application . . . today make Lebanon the choice of those who insist on fine craftsmanship and expert design.

The famed Circle Ⓛ now marks castings made in more than thirty different alloys. These Lebanon Steels cover a broad range of applications in many fields.

The right men using the right methods for the right kind of American defense—that is the immediate picture at Lebanon. Meanwhile, Lebanon metallurgists are studying future applications for stainless steel castings . . . and are ready to discuss significant developments with forward looking organizations.

LEBANON STEEL FOUNDRY • LEBANON, PA.

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *Stainless and Special Alloy* **STEEL CASTINGS** CIRCLE L

TIME *Marches On*

In 1921, NORMA-HOFFMANN introduced the Cup Mounting—the forerunner of all-self-protected ball bearings. From this, through progressive stages (as shown above) has evolved the NORMA-HOFFMANN "CARTRIDGE" BALL BEARING—an ultra-modern type embodying 30 years of PRECISION BEARING manufacture and offering to industry the following distinctive advantages:

SIMPLER AND MORE ECONOMICAL MACHINE DESIGN, due to elimination of many costly mounting parts and machining operations, otherwise required; EASIER AND FASTER MACHINE ASSEMBLY AND DISASSEMBLY, since the "CARTRIDGE" BEARING is an integrally sealed unit needing no complementary mounting parts; 100% GREATER GREASE CAPACITY, due to double-row width creating a greatly enlarged grease reservoir; COMPLETE AND LASTING EXCLUSION OF DIRT AND FOREIGN MATTER by the use of tightly fitting, wearless, all-metal seals; SEALED FOR ANY POSITION, since the seals retain the lubricant regardless of shaft angle; EASY REGREASING AND INSPECTION WITHOUT DISMOUNTING, by means of refilling plug and removable seals.

Write for the Catalog. Submit your bearing problems for study and recommendation, without obligation. NORMA-HOFFMANN sales and service engineers, and distributors in principal cities stocking "CARTRIDGE" BEARINGS, are at your service.

"NORMA-HOFFMANN"

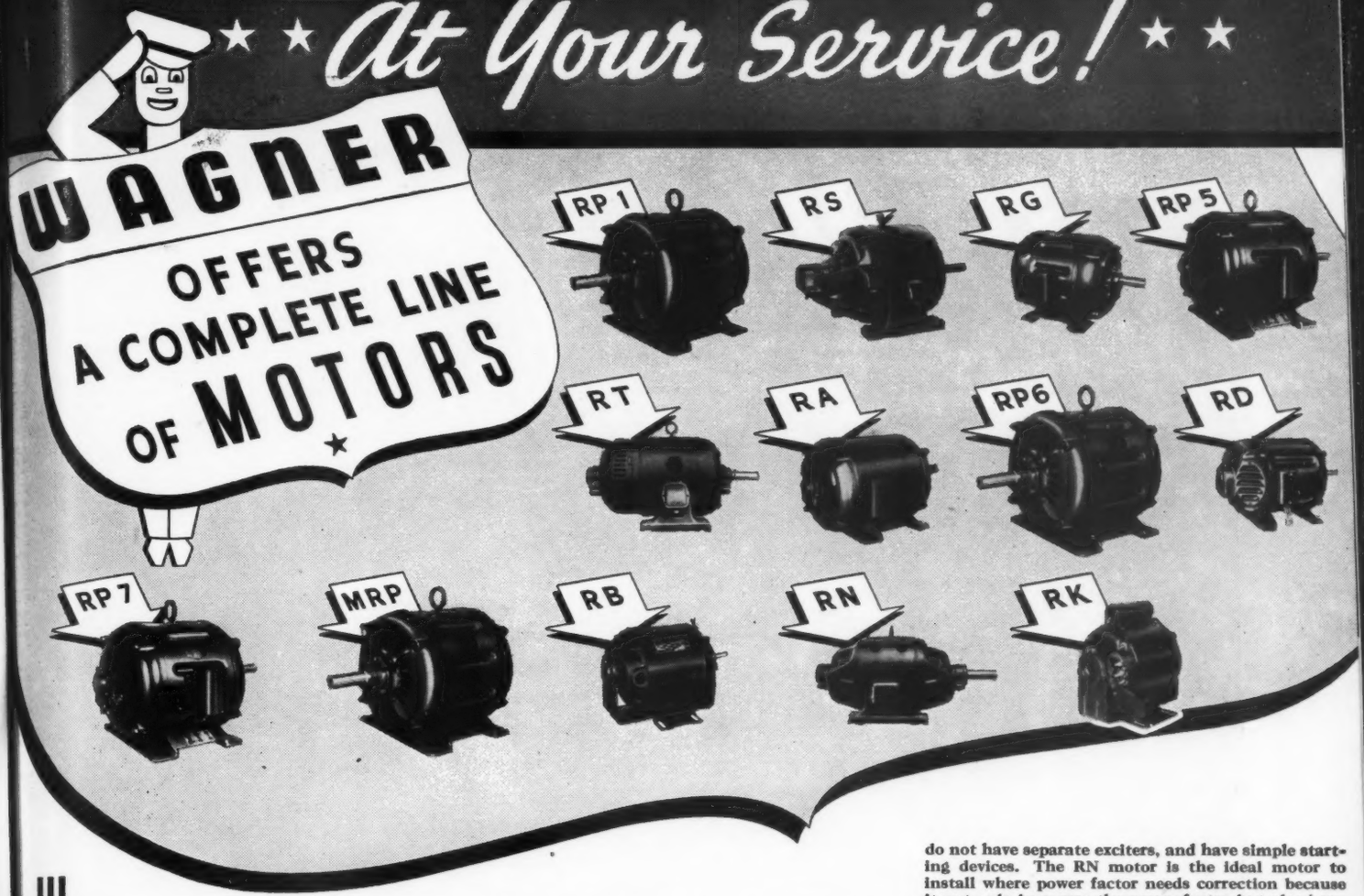
CARTRIDGE

BALL BEARING

PRECISION BALL, ROLLER and THRUST BEARINGS

NORMA-HOFFMANN BEARINGS CORP'N., STAMFORD, CONN., U.S.A. • FOUNDED 1911

★ ★ At Your Service! ★ ★



WAGNER motors may be broadly divided into three general classes: polyphase, single-phase, and direct-current. The following outline shows the various subdivisions and the Wagner type letters which apply to them.

1. **Polyphase**
   - *A. Squirrel-Cage Rotor*
     1. Low resistance Type RP-1
     2. High reactance Type RP-5
     3. High resistance Type RP-6, RP-7
   - *B. Wound Rotor*
     1. Low resistance Type RS
     2. High resistance Type RT
     3. Synchronous Type RN
2. **Single-Phase**
   - *A. Wound Rotor*
     1. Repulsion start Type RA
     2. Repulsion-induction Type RG
   - *B. Squirrel-Cage Rotor*
     1. Capacitor-start Type RK
     2. Split-Phase-start Type RB
3. **Direct-Current**
   - *A. Wound Rotor*
     1. Compound-Wound Type RD

Polyphase Squirrel-Cage Low-Resistance (1/6 to 400-hp)
Because of its simplicity, rugged construction, and low cost the RP-1 motor is the most popular type used in industrial plants. It has sufficient starting-torque for operating machine tools, fans and blowers, centrifugal pumps, some types of compressors, and many other kinds of machinery.

Polyphase Squirrel-Cage High-Reactance (1-1/2 to 125-hp)
Some applications require motors of higher starting-torque than obtainable in RP-1 motors. Typical examples are crushers, plunger pumps, belt conveyors starting under load, large air compressors, large refrigerating machinery, mixers, etc. For such applications Wagner builds a high starting-torque motor with high-reactance rotor, known as type RP-5.

Polyphase Squirrel-Cage High-Resistance (1/2 to 150-hp)
The motors discussed thus far are not suitable for operating machines having heavy flywheels because these motors will not permit the flywheels to deliver enough of their stored energy during the punching or drawing operation. For these applications Wagner builds RP-6 motors with high-resistance rotors. During the working part of the cycle, the motor speed drops considerably and allows the flywheel to do its work. High-resistance rotors are also used in RP-7 (1 to 50-hp) elevator motors, which are used on low-speed elevators, hoists, dumb waiters, etc.

Polyphase Wound-Rotor Low-Resistance (1 to 250-hp)
There are two reasons for the existence and application of motors of the Wagner type RS. First, since the rotor winding is connected to slip-rings making it easy to connect a high external resistance in the rotor circuit, it is possible to obtain extremely low starting-currents without impairing the running performance. Second, by introducing resistance in the rotor circuit of an RS motor it is possible to obtain speeds from 50 to 97% of synchronous speed. This method of speed control is satisfactory when the load is constant. For obtaining different speeds on applications where the load varies, Wagner recommends the use of polyphase squirrel-cage multi-speed motors, type MRP, which may be obtained with two, three, or four speeds.

Polyphase Wound-Rotor High-Resistance (40 to 100-hp)
The air-conditioning industry sometimes requires motors which must have higher starting-torques and lower starting-currents than can be obtained in good squirrel-cage motors. For such applications the Wagner RT motor was developed. The characteristics of unusually high starting-torque and exceptionally low starting-current are accomplished by using a high-resistance secondary winding which is permanently short-circuited.

Polyphase Wound-Rotor Synchronous (7-1/2 to 200-hp)
Wagner Synchronous "Fynn-Weichsel" motors, type RN, differ from conventional synchronous motors in that they have starting characteristics like RS motors, do not have separate exciters, and have simple starting devices. The RN motor is the ideal motor to install where power factor needs correction because it not only improves the power factor but also handles the toughest job to be found.

Single-Phase Wound-Rotor Repulsion-Start (1/8 to 15-hp)
For single-phase circuits there is no better motor than the Wagner RA repulsion-start induction motor, which starts as a repulsion motor with high starting-torque and low starting-current, and, upon approaching operating speed, is automatically converted into an induction motor. With few exceptions, if single-phase current is involved, the RA motor is the logical choice.

Single-Phase Wound-Rotor Repulsion-Induction (1 to 5-hp)
Filling-station compressors are often operated in cold locations under weather conditions which congeal the oil in the compressor crankcase and may increase the load until it is double its normal value. For such applications Wagner produced the RG motor which is a brush-riding machine with a squirrel-cage to limit the idle speed. This type of motor will carry any load which it can start and is ideal for filling-station compressor applications.

Single-Phase Squirrel-Cage-Rotor Capacitor-Start (1/6 to 1-hp)
In order to meet a competitive situation Wagner builds the RK motor, which is a capacitor-start induction machine.

Single-Phase Squirrel-Cage-Rotor Split-Phase-Start (1/20 to 1/3-hp)
The cheapest type of single-phase motor is the RB split-phase machine. It is recommended for applications where the starting duty is light and the period of acceleration is short. The RB-5 (1/6, 1/4 and 1/3-hp) is a special service motor intended for washing machines, mangles, etc., which operate only for a short period of time at infrequent intervals. The RB-5 motor should not be used on jobs which operate continuously.

Direct-Current Wound-Rotor Compound-Wound (1/6 to 3-hp)
Wagner also builds direct-current type RD motors, which are still required in some locations.

***Send for Bulletins* MU-177, MU-179, MU-182 *describing* WAGNER Motors**

M41-30

WAGNER ELECTRIC CORPORATION 50TH 1891 • 1941 ANNIVERSARY ST. LOUIS, MO.

50 YEARS OF SERVICE

This year Wagner celebrates its fiftieth year of service to industry and the home—as a manufacturer of motors, transformers, and fans of the highest quality.

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

MOTORS • TRANSFORMERS • FANS • BRAKES

THE HEAD has it!

"UNBRAKO"
Knurled Socket Head Cap Screws

Yes . . . the head has it, and it's KNURLING—famous "Unbrako" feature for years and at no extra cost!

Today the speed-up advantages of KNURLING are being realized more than ever before. Dry or greasy fingers gear right to dry or greasy knurls and prevent annoying time-wasting slip—be it a job of assembling or adjustment. And the KNURLING also permits quick, easy locking of the screw after countersinking.

"UNBRAKO" Knurled Self-Locking Hollow Set Screws

No less famous is the self-locking feature of "Unbrako" Hollow Set Screws . . . and once again it's KNURLING that does the trick by locking the screw firmly in place after having been pulled up with no more than average pressure. No matter how severe the vibration, you can count on the "Unbrako" Self-Locker to *stay set!* Yet it's easily applied or removed and can be used repeatedly.

Be sure to make your next order "UNBRAKO". You'll find it pays in many ways.

The KNURLING of Socket Screws originated with "UNBRAKO" years ago.

STANDARD PRESSED STEEL CO.
JENKINTOWN, PENNA. Box 545
— BRANCHES —
BOSTON • DETROIT • INDIANAPOLIS • CHICAGO • ST. LOUIS • SAN FRANCISCO

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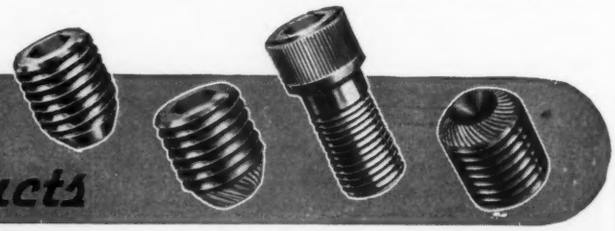
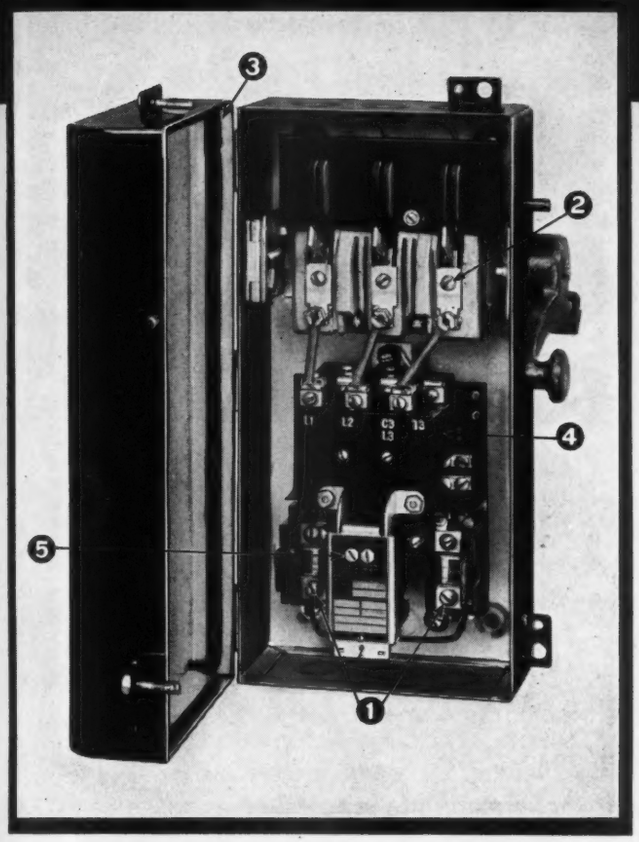
UNBRAKO *Screw Products*



THE OPERATING AND MAINTENANCE ELECTRICIANS VOTED SQUARE D



SQUARE D COMPANY	98
COMPANY A	94
COMPANY B	91
COMPANY C	91
COMPANY D	84
COMPANY E	72
COMPANY F	71

● One of the largest automobile plants recently made comparative tests of all makes of magnetic starters. Size 1 combination starters with disconnect switch were used. The tests were made under the supervision of the chief electrician and his assistant. The Starters built by the seven leading manufacturers passed with varying degrees of merit.

The chief electrician, wisely, wanted the independent opinion of the men who actually install, use and repair the electrical equipment. Five of his best men, two from the construction and three from the maintenance department, were asked to examine and rate the seven starters on the basis of (1) overload relays (2) disconnect switch (3) cabinet construction (4) contact mechanism and rupturing capacity and (5) accessibility of parts. The best or equal starter for each feature was scored with 20 points; the others were penalized a relative number of points. The results (as shown in chart above) speak for themselves.

It's the electrician in the factory who knows how control apparatus performs year in and year out. It's his job to inspect it—replace parts when required—above all to avoid costly shut-downs. These plant electricians prefer Square D electrical equipment of all types and kinds.

1 Thermal overload relays of Melting Alloy type. Patented unit construction prevents faulty installation and permits factory test. Units are clearly marked and easily exchanged.

2 Motor circuit switch with quick make and break action, visible blades, line terminal guard and cover safety interlock.

3 Cabinet of heavy gauge sheet steel with felt cover gaskets (NEMA 1A), provisions for padlocking, rounded cover, and baked machine blue enamel finish with aluminum interior.

4 Contact mechanism has straight line, vertical action with double break silver contacts in an enclosed arc chamber to provide high rupturing capacity.

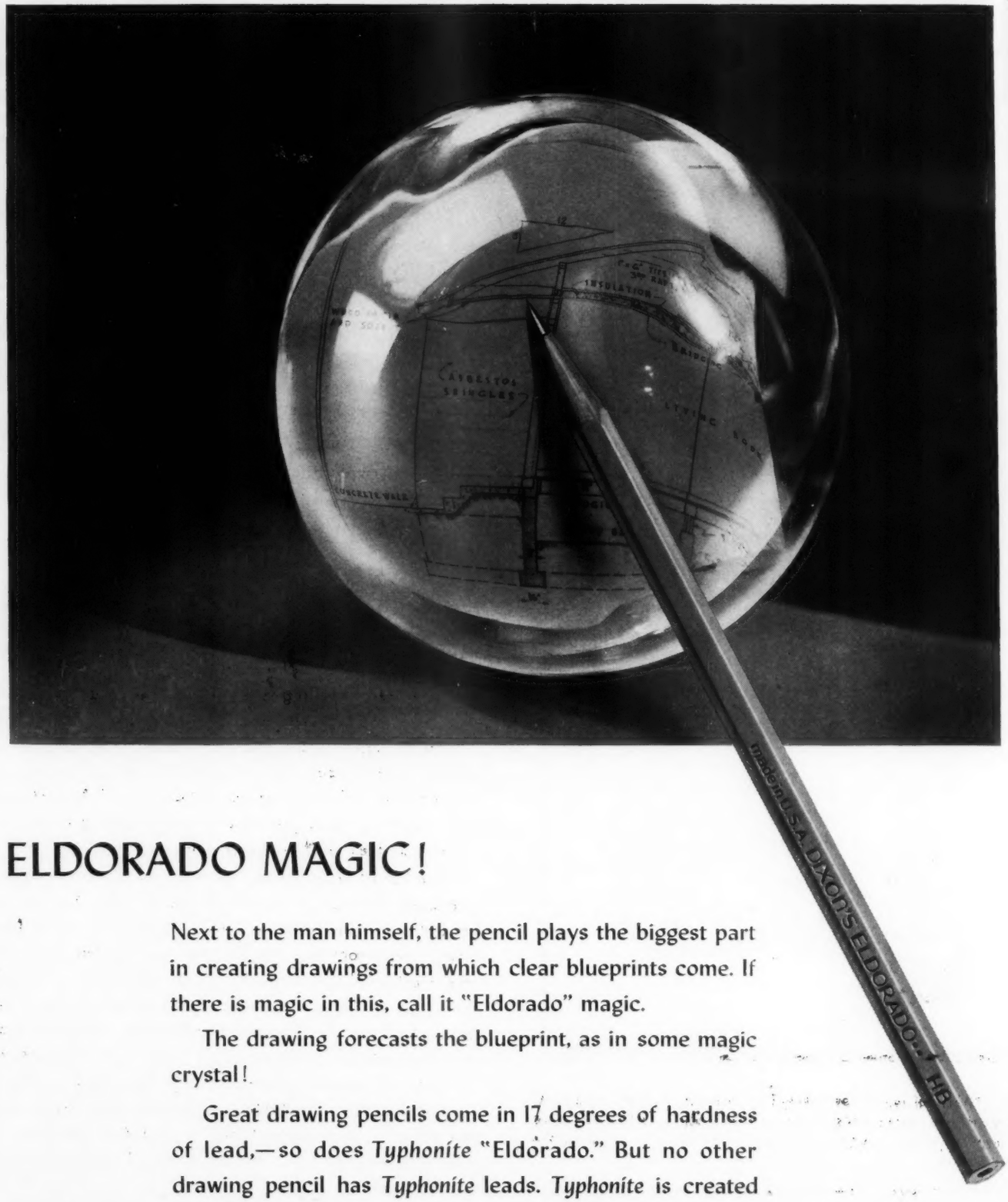
5 Accessibility of parts is accomplished without sacrifice in size. Removal of two screws permits armature assembly and yoke bar to be taken off, exposing all parts for inspection or normal maintenance.

SQUARE D COMPANY

DETROIT - MILWAUKEE - LOS ANGELES

KOLLSMAN INSTRUMENT DIVISION, ELMHURST, NEW YORK

IN CANADA: SQUARE D COMPANY CANADA LIMITED, TORONTO, ONTARIO



ELDORADO MAGIC!

Next to the man himself, the pencil plays the biggest part in creating drawings from which clear blueprints come. If there is magic in this, call it "Eldorado" magic.

The drawing forecasts the blueprint, as in some magic crystal!

Great drawing pencils come in 17 degrees of hardness of lead,—so does *Typhonite* "Eldorado." But no other drawing pencil has *Typhonite* leads. *Typhonite* is created in a literal whirlwind from natural graphite. There is no stopping the whirlwind and there is no stopping Dixon *Typhonite* "Eldorado" as it whirls along far in the lead.

PENCIL SALES DEPARTMENT 20-J12 • JOSEPH DIXON CRUCIBLE CO. • JERSEY CITY, N. J.

Resinox

ADDS A LUXURY NOTE TO THE DASHBOARD . . .

Smooth and lustrous, with all the rich color and grain pattern of a fine cabinetworker's masterpiece—that's a quick description of this automobile radio grille molded of Resinox, Monsanto's phenol-formaldehyde molding compound, by Bay Manufacturing Division, Electric Auto-Lite Company.

Designed as an integral part of the dashboard, to simulate beautifully grained mahogany, it adds a new note of luxury to one of the most beautifully styled, popular-priced cars.

But that's just half the story.

Here, as in nearly all the jobs for which Resinox is enlisted, important production economies were achieved at the same time new beauty and style were added. The grille emerges from the mold practically ready for installation with little finishing and no further assembly operations needed.

For more information on Resinox, its future possibilities in *your* products, and the names of competent molders, inquire: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield, Massachusetts. District Offices: New York, Chicago, Detroit, St. Louis, Birmingham, San Francisco, Los Angeles, Montreal.

THE FAMILY OF SIX MONSANTO PLASTICS

(Trade names designate Monsanto's exclusive formulations of these basic plastic materials)

LUSTRON (polystyrene) • OPALON (cast phenolic resin)
NITRON (cellulose nitrate) • FIBESTOS (cellulose acetate)
SAFLEX (vinyl acetal) • RESINOX (phenolic compounds)

Sheets • Rods • Tubes • Castings • Molding Compounds
Vuepak, Rigid Transparent Packaging Materials

MONSANTO PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

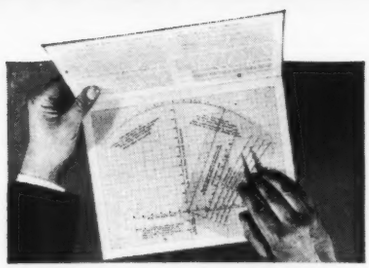
KEEP THEM GOING WITH HYATTS

NO MATTER WHAT THE APPLICATION

Precision built... great in capacity... Hyatts are helping to lighten the loads of all mechanized defense equipment.

Meanwhile, Hyatts still are serving in their regular, and now more essential than ever, role of keeping free from bearing wear and care the machinery which produces this defense equipment.

Therefore remember, today as always, that where the loads are heavy and the going is tough you can depend on Hyatt Roller Bearings for any application.



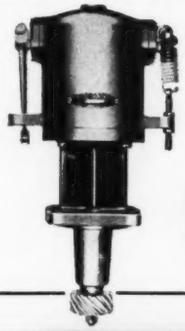
FREE TO MACHINE DESIGNERS

HYATT GEAR THRUST CALCULATOR – valuable timesaver for designers and engineers. Request in writing on your company letterhead – address Advertising Department, Hyatt Bearings Division, General Motors Sales Corporation, Harrison, N. J.

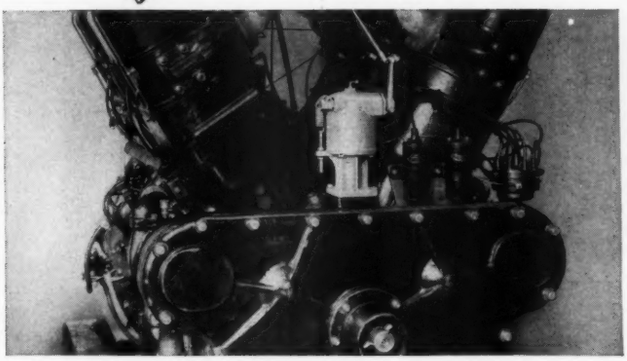
HYATT

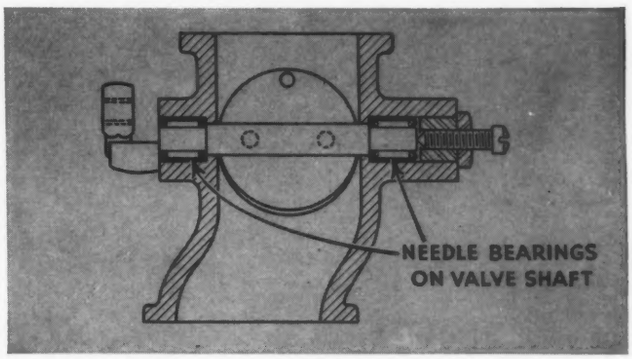
ROLLER BEARINGS

QUIET



TORRINGTON NEEDLE BEARINGS *SIMPLIFY DESIGN,* REDUCE FRICTION FOR PIERCE GOVERNOR





"TORRINGTON NEEDLE BEARINGS ARE 'BLITZING' FRICTION LAG in many Pierce Governors where the critical demands of defense needs require friction-free operation," says Maynard L. Heacox, of the Pierce Governor Company. Pierce Governors are being used today to control power for defense in tanks, trucks, searchlights, field radio apparatus and in many other important applications such as that shown above on a LeRoi gasoline engine.

LOW INITIAL COST, EASY INSTALLATION and efficient lubrication are three of the many advantages obtained by Pierce Governor through the use of Needle Bearings on valve and rocker shafts. The precision-ground rollers and hardened outer race of these bearings form a self-contained unit that is speedily, inexpensively installed. And maintenance cost is low because lubricant is retained by the turned-in lips of the race.

"TO MEET RIGID WEIGHT AND SPACE LIMITATIONS, Torrington Needle Bearings are also used on the flyball weight pivots of Pierce Governors," adds Mr. Heacox. Here these compact bearings occupy no more space than ordinary bushings, yet substantially reduce oscillation friction.

FAVORABLE WEIGHT DISTRIBUTION, too, makes Needle Bearings ideal for weight pivot work, according to Mr. Heacox. The many linear inches of contact made possible by this bearing's numerous rollers provide an exceptionally high radial load capacity in proportion to its size.

Perhaps a small, lightweight, anti-friction bearing can give *your* product valuable advantages. Remember that Torrington Needle Bearings take no more space than bushings, yet provide exceptionally high load capacity with a minimum of wear and attention. Write for Catalog No. 108 and

find out the complete details about this compact, low-cost bearing. Our Engineering Department will be glad to answer any questions. For information on Needle Bearings to be used in heavier service, write our associate, Bantam Bearings Corporation, South Bend, Indiana, for Booklet 104X.

THE TORRINGTON COMPANY, TORRINGTON, CONN., U. S. A. · ESTABLISHED 1866

Makers of Needle and Ball Bearings

New York Boston Philadelphia Detroit Cleveland Chicago Los Angeles London, England

TORRINGTON NEEDLE BEARING

VICKERS

Gear Type FLUID MOTORS

DEVELOP ROTARY MECHANICAL POWER FROM OIL HYDRAULIC PRESSURE

VICKERS Exclusive Hydraulic Balance Construction

means much

(1)
LONGER LIFE

(2)
HIGHER EFFICIENCY

(3)
GREATER PRACTICAL OPERATING PRESSURE

(4)
MORE COMPACT

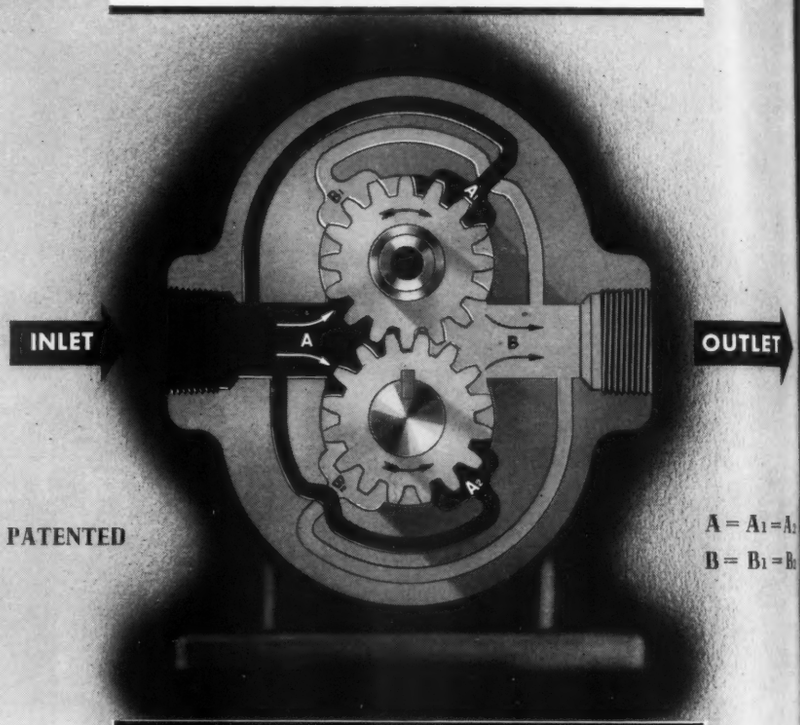
Vickers Gear Type Fluid Motors provide a compact efficient means for applying variable speed rotary power. They have variable horsepower (fixed torque type) characteristics; they can be reversed and controlled readily by other Vickers Hydromotive Control devices in the circuit.

The schematic diagram shows how Vickers patented "Hydraulic Balance" construction is applied to Vickers Gear Type Fluid Motors. This "Hydraulic Balance" construction and its advantages are available on no other fluid motors.

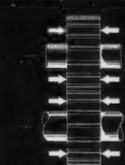
Here is further evidence of the engineering development and research that assures the unique performance of all Vickers Hydromotive Equipment.

VICKERS *Incorporated*
1454 OAKMAN BLVD., DETROIT, MICHIGAN

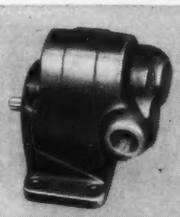
Bearing Loads are Cancelled Out



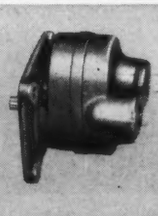
RADIAL BALANCE AXIAL BALANCE



VICKERS Offers Complete Hydraulic Balance, Both Radial and Axial, to Eliminate Pressure Loads



Foot Mounted, Side Ports



Flange Mounted, End Ports

See Bulletin 40-23 for complete information

SELF LUBRICATING BRONZE BEARINGS

SUBSTITUTION
offers an unusual opportunity to IMPROVE

★ As the big job of arming the nation strains the resources of the country, many manufacturers are finding it necessary to seek substitutes in the production of their product. This does not necessarily mean a compromise with quality . . . rather, it offers an unusual opportunity for improvement.

Consider the use of Johnson LEDALOYL, a patented, self-lubricating bronze . . . the newest development in powder metallurgy. Within the past year LEDALOYL has supplemented small but important parts formerly made from zinc . . . steel . . . other metals and materials. In practically every case there was a distinct improvement in performance . . . longer life . . . economy.

An exclusive process of PRE-ALLOYING the basic materials of LEDALOYL provides uniform structure . . . uniform strength . . . dependable lubrication . . . the addition of lead as an integral part. These are but a few of the many factors that contribute to the unusual performance of LEDALOYL. Write today for complete details.

New Catalogue

Listing over 2000 sizes of Johnson LEDALOYL for which we have tool and die equipment. This includes plain, flanged and self-aligning bearings. Write for a copy.

JOHNSON BRONZE COMPANY
Sleeve Bearing Headquarters
508 S. MILL STREET NEW CASTLE, PENNA.

SALES OFFICES AND WAREHOUSES
ATLANTA BALTIMORE BOSTON BUFFALO CHICAGO CINCINNATI CLEVELAND DALLAS DETROIT KANSAS CITY LOS ANGELES HOUSTON
MINNEAPOLIS NEW CASTLE NEW YORK CITY NEWARK PHILADELPHIA PITTSBURGH PORTLAND ST. LOUIS SAN FRANCISCO SEATTLE

You have no time to experiment-

be sure-use CHROMALOX Electric HEATING UNITS!

Whether you're on direct defense work, or designing equipment to speed defense production — if heat is involved, consider electric heat.

You have no time to experiment. Fortunately, there may be no need to experiment. The probabilities are that the research and experimental development on your electric heating problem have already been done, and the records and results are on file in our engineering department.

This data is at your service, with the cooperation of a corps of electric heating experts whose record of achievement is fully equal to that of Chromalox units. Check with these specialists on your heating problem—they may save you time, worry and expense, besides insuring the selection of the right electric unit for the job, and the best means of its application. Write, wire or 'phone today.

•

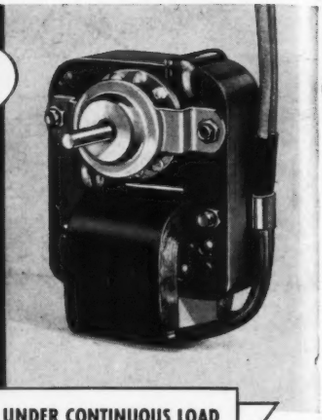
"The Chromalox Book of Electric Heat" is praised by design engineers everywhere. It contains a wealth of information. Mail the coupon with your letterhead today.

EDWIN L. WIEGAND COMPANY
7535 Thomas Blvd. Pittsburgh, Pa.
Send me the CHROMALOX BOOK OF ELECTRIC HEAT
Name..... Position.....12

ALLIANCE MODEL "K" MOTOR

Built for Years of Service

Powered for 1000 uses!



DEVELOPS UP TO 1/100 H. P. UNDER CONTINUOUS LOAD

Scores of uses such as driving fans, movie projectors, and other light home appliances, powering toys, motion displays, switches and control systems—these and many other applications have proved the lasting dependability of Alliance's line of inexpensive small motors.

The recently designed, Model K shaded pole induction motor, illustrated above, is the last word in efficient small motor design. When quantity warrants, this motor can be furnished with variations to adapt the basic motor to a specific application. Model K can be produced in all standard voltages and frequencies with actual measured power outputs ranging upwards to 1/100 H.P. Greater outputs can be obtained, when used for intermittent duty only or where forced ventilation is provided. A two pole design is employed with no load rotor speeds of approximately 3450 R.P.M.

Finest materials and precision manufacturing assure long life and freedom from breakdowns.

Write today for further information. Address Dept. G.

ALLIANCE MFG. CO. • ALLIANCE, OHIO

We're Ready to Go to Work!

Stackpole Offers You Facilities to Immediately Produce

SMALL PARTS and SUB-ASSEMBLIES

for Your Defense Contracts

Our entire resources are available for making small parts and sub-assemblies under your defense contracts and to help solve production problems involving Switches, Resistors, Iron Cores and other units for use in radio and electrical instruments, motors, etc. We invite manufacturers to share our experience and efficiency in designing and producing various types of small units. Our engineers will be glad to go into full details, without obligation.

At Your Service

- **Bakelite Modeling Equipment** for parts and sub-assemblies for equipment, instruments, etc.
- **Complete Punch Press Dept.** operated by engineer-craftsmen.
- **Complete Assembly Equipment** for production of small parts.

STACKPOLE CARBON COMPANY
ST. MARYS, PENNSYLVANIA, U. S. A.

Accurate Timing . . FOR A·C·RESISTANCE WELDERS

More accurate and consistent in its timing within the range of times required for production welders than mechanical timers is this "3C" Bulletin 7744 Weldmaster Electronic Welding Timer.

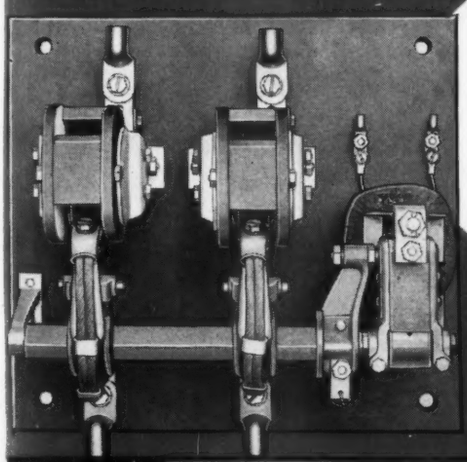
Under varying voltage conditions its time is very well maintained.

Time settings from 2 to 30 cycles based on a 60 cycle circuit, adjustable in 30 steps are provided . . . Indexed dials enable the timer to be reset exactly to any previously used time period . . . There's no guessing nor fumbling in resetting—the dials permit accurate resetting.

One Electronic tube, of low cost, replaceable through radio tube manufacturers' distributors, and one sturdy commercial Relay are used . . . All other devices are not movable, are not affected by frequency of operation, and the entire timer gives exceptionally long, trouble free life.

Fully descriptive Bulletin 7744 is yours for the asking.

"3C" Bulletin 7744 WELDMASTER Electronic Timer for A.C. Resistance Welders.



TO THE LEFT is shown a "3C" Bulletin 7740 A. C. Magnetic High Speed Welding Contactor . . . It is specially designed to meet extreme, exacting service conditions in resistance welding applications.

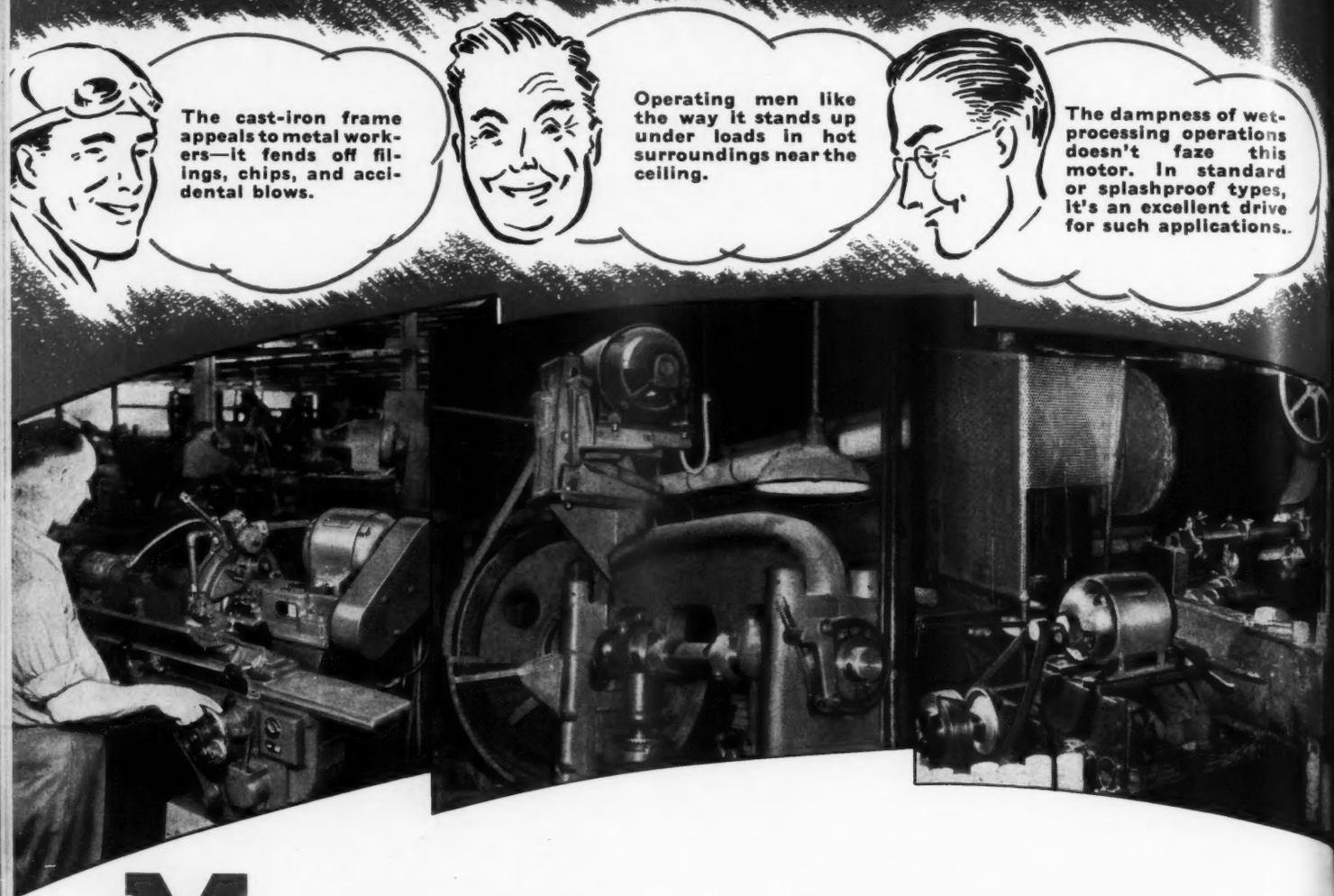
It features a light weight moving armature, high speed closing with minimum impact, spring as well as gravity opened, large size duplicate, hard drawn copper contact tips . . . adjustable contact spring pressure, and adjustable contact gap. Write for fully descriptive Bulletin 7740.

OFFICES IN PRINCIPAL CITIES

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO

NOW YOU'RE TELLING US.....


The cast-iron frame appeals to metal workers—it fends off filings, chips, and accidental blows.
Operating men like the way it stands up under loads in hot surroundings near the ceiling.
The dampness of wet-processing operations doesn't faze this motor. In standard or splashproof types, it's an excellent drive for such applications..

Motor users are proving the case

FOR TRIPLE PROTECTION.....MODERN DESIGN

ACTIONS speak louder than words. In the short time that they have been available, Tri-Clad motors have won a host of friends in a wide variety of industries because of the way they stand up under trying operating conditions. More significant, however, than the extent of their use are the applications in which Tri-Clad motors are seeing "front-line" service. Here are a few tough spots in which they are proving their mettle:

On equipment which must operate in hot or damp surroundings, or where the motor is subjected to flying chips or falling objects—*extra protection against physical damage* keeps these motors going in spite of this unavoidable abuse.

On equipment responsible for vital defense production—*extra protection against electrical breakdown* helps to assure continuity of operation 'round the clock.

On equipment which must perform month in and month out without babying by the maintenance crew—*extra protection against operating wear and tear* prolongs the years of smooth, quiet service.

On equipment which is expected to *look attractive* by virtue of smoothly contoured modern design, the functional styling of the Tri-Clad fits in perfectly.

Why not give Tri-Clad motors a chance to show you just what continuous, economical motor operation is? Next time you order a motor or a motor-equipped machine, specify Tri-Clad. *General Electric Company, Schenectady, N. Y.*

GENERAL ELECTRIC

750-92-8058

...WHY TRI/CLAD IS TOPS

REG. U.S. PAT. OFF.

Plant men find Tri-Clad motors easy to maintain. Lubrication features facilitate quick oiling or greasing. Smooth contours can be readily cleaned.

Tri-Clad motors are a cinch to install. Electricians like them because of the roomy conduit box and the permanently identified terminals.

Machine builders and buyers both like the way that these motors blend in with the neat, attractive appearance of modern machines.

GENERAL ELECTRIC

TRI/CLAD

MOTOR

Tri-Clad induction motors are now being produced in 16 fundamental electrical types and 8 basic mechanical constructions. Call your local G-E motor representative for information on availability of types and sizes to meet your needs.

BUILT FOR PROTECTION FIRST...TO LAST!

5 WAYS TO APPLY *Electric Heat* TO YOUR MACHINES

These G-E heaters are economical, long-lasting, and easy to install

CALROD HEATERS

Available in straight lengths or shaped to suit your application. Ratings and finishes for practically every job involving the heating of liquids, soft metals, or metal surfaces. Easy to install and can be placed exactly where required. Heaters with allowable sheath temperatures as high as 1500 F.

CARTRIDGE HEATERS

Highly suitable for heating process machinery. Small enough to be put right at the spot where heat is needed. Drill a hole and insert heater right into the metal. Diameters from 3/8 to 1.293 inch—lengths from 1½ to 8½ inches. Temperatures up to 1200 F.

IMMERSION HEATERS

Most economical method of heating liquids. Heaters are of sizes and shapes to fit your machines. Permanently sealed to prevent the entrance of moisture.

STRIP HEATERS

Can be used as air heaters or as clamp-on units for metal surfaces. Enameled finish defies rust and corrosion. Available with various terminal arrangements, including offset construction that makes parallel connections easy. Temperatures up to 1200 F.

FIN CALROD HEATERS

Used for forced-air heating in ducts and process machinery. Copper-brazed fins provide low heat density and form a compact and durable heater. Constructed to permit bending into various forms without loosening fins or reducing efficiency.

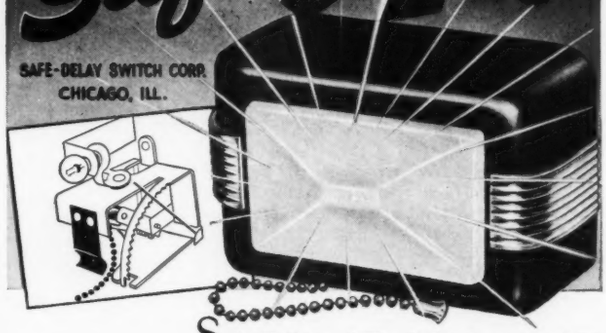
These heaters are easily installed in your machines, and they can be controlled automatically. The cleanliness, convenience, accuracy, safety, and economy of electric heat will please your customers. This means greater sales.

G-E heaters are constructed for machine application. They are reasonably priced. For full information, including prices, ask the nearest G-E office for Catalog GED-650A. General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

675-37-8709

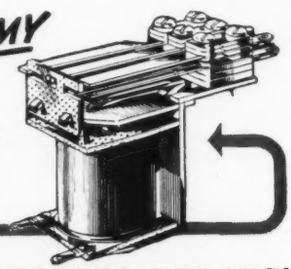
"WE USE CHACE HIGH-TEMPERATURE Thermostatic BIMETAL IN THE Safe-D-Lite"



Safe-D-Lite, *"The light that goes OFF by itself."* The new wall light that requires no wiring . . . hangs anywhere . . . light it—leave it—light goes out automatically . . . adjustable timing range from a few seconds to several minutes . . . uses two standard flashlight batteries. This manufacturer chose Chace Thermostatic Bimetal to assure dependable, automatic shut-off. Today, more than ever before, manufacturers depend upon Chace Thermostatic Bimetal for the reliable automatic control of their products.

W. M. CHACE CO.
1607 Beard Avenue - - - Detroit Mich.

GET THE ECONOMY THAT COMES WITH QUALITY



IN AUTOMATIC ELECTRIC RELAYS!

Automatic Electric relays are world-famous for quality. Tested by time through years of exacting use . . . constantly improved by endless laboratory tests . . . backed by the "know how" gained from 50 years of specialized manufacturing experience—these relays give you the superior performance and long life that mean genuine economy.

The complete Automatic Electric relay line includes units for every operating condition. All are characterized by positive action and dependability—for which you pay no premium.

Send for your free copy of our comprehensive relay catalog.

AMERICAN AUTOMATIC ELECTRIC SALES COMPANY
1033 W. Van Buren Street, Chicago

AUTOMATIC ELECTRIC
RELAY MAKERS SINCE 1898

THAT EXTRA SOMETHING

DUMORE

FRACTIONAL HORSEPOWER

MOTORS

Precision performance marks a champion of the ski-ways. And precision performance has made Dumore motors the champions of extra "Power Hours". On business machines . . . surgical and scientific instruments . . . household appliances . . . electric tools . . . delicate aircraft controls . . . wherever packaged power is needed for maximum performance with minimum size and weight, you'll find Dumore fractional horsepower motors setting records. Why not put a champion to work on your own power problem? A letter to Dumore engineers gets the *right* answer. There's no obligation.

THE DUMORE CO., Dept. 331-M, Racine, Wis.

SPECIFICATIONS FOR TYPE E2X MOTOR

Voltage, 12 or 24; h. p. output, 1/30; r.p.m., 7500; continuous duty; explosion-proof; varying speed; weight, 2 lbs. 2 oz., bearings, grease-sealed ball. Conforms to Air Corps specifications.

FOR HIGH TORQUE, LOW MAINTENANCE AND ALL-ROUND PERFORMANCE

These quiet motors are available in ratings from 1 8-hp through 3 4-hp in all standard voltages and frequencies.

YOU CAN'T BEAT THIS G-E CAPACITOR-MOTOR

WHEN YOU NEED A MOTOR THAT

. . . . . has high torque, is quiet running, and has constant speed.

. . . . . is especially suitable for such machines as water pumps, compressors, beverage coolers, room coolers, stokers, unit heaters, refrigerating equipment, and many other applications.

. . . . . does not interfere with radio reception.

. . . . . requires no attention except for infrequent lubrication.

. . . . . will stay on the job day in, day out.

CONSIDER THE GENERAL ELECTRIC CAPACITOR-MOTOR

You can rely on it to give the sort of motor performance that you want.

Our engineers will be glad to work with you in solving your motor problems. For this service, contact the nearest G-E sales office, or write General Electric, Schenectady, N. Y.

And remember that there is a complete line of G-E fractional-hp motors.

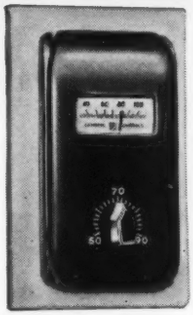
GENERAL ELECTRIC

200-46-8260

NOW MORE THAN EVER Personal ATTENTION COUNTS

No Room for Error!

GENERAL CONTROLS relies on WILCO Thermometals



"No compromise with quality" is a "must" with General Controls Co., maker of this sensitive thermometer-thermostat. And as the pioneer in use of bi-metals for thermometers as well as thermostats, it is only natural that General Controls relies exclusively on *Wilco* Thermometals. For commercial or defense purposes, you too will find that *personal supervision* of every order by Wilco principals assures maximum uniformity, minimum "rejects".

And just as Wilco meets these exacting requirements for thermometals to provide absolute dependability for temperature control — or reaction from temperature change—so do Wilco Electrical Contacts assure dependable service. For full information, write us today.

WILCO

The H. A. WILSON CO.
105 CHESTNUT ST., NEWARK, N. J.
Branches: Chicago and Detroit

FENWAL THERMOSWITCH SELECTED FOR *Extreme Sensitivity*

This rugged, compact heat control has been recently selected for its "extreme sensitivity" by a prominent manufacturer for incorporation in his tankless water heaters. It features a 1-1/10° differential and there is practically no Thermal lag. Perhaps this precise dependable Thermo-Responsive Switch is the answer to your heat control problem. May we tell you more about it?

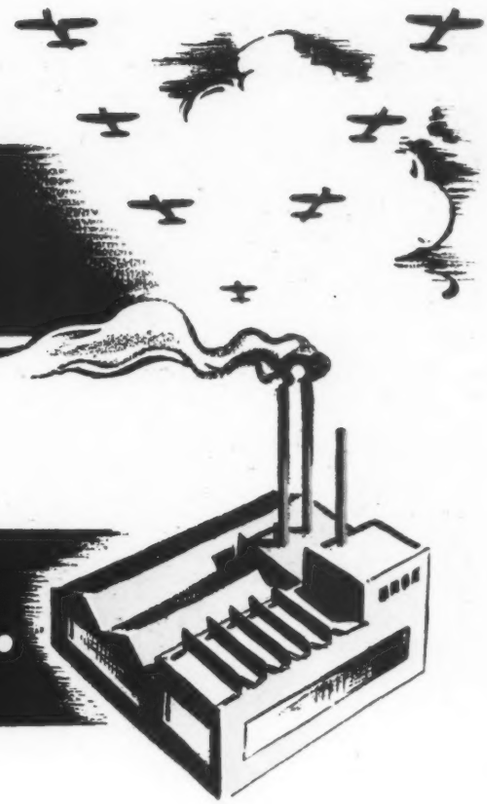
Illustrated: "Hex" type, with junction box attached permits use of graduated dial and knob and lead wire protection. Range — 50° F.-400° F. Rating 10 Amp. 115 V., 5 Amp. 230 V., 25 Amp. 115 V. also available.

Fenwal INCORPORATED

30 MAIN STREET
ASHLAND MASSACHUSETTS

Protection today . . .

Progress tomorrow . . .



with EVERDUR!

You would naturally expect this high-strength, workable, weldable copper-silicon alloy to be serving national defense in many ways. It is—in every armed service, and in the production equipment of many war-vital industries.

For good reasons, too!

Where and why Everdur is used in National Defense . .

ANACONDA THE AMERICAN BRASS COMPANY • WATERBURY, CONNECTICUT

Everdur hull fastenings help keep Coast Guard and "PT" boats tight and secure against the sea. Sheet Everdur is also extensively used for fuel tanks and non-magnetic pilot house construction in Coast Guard boats.

Everdur

HELPS TOUGHEN THE SINEWS OF NATIONAL DEFENSE

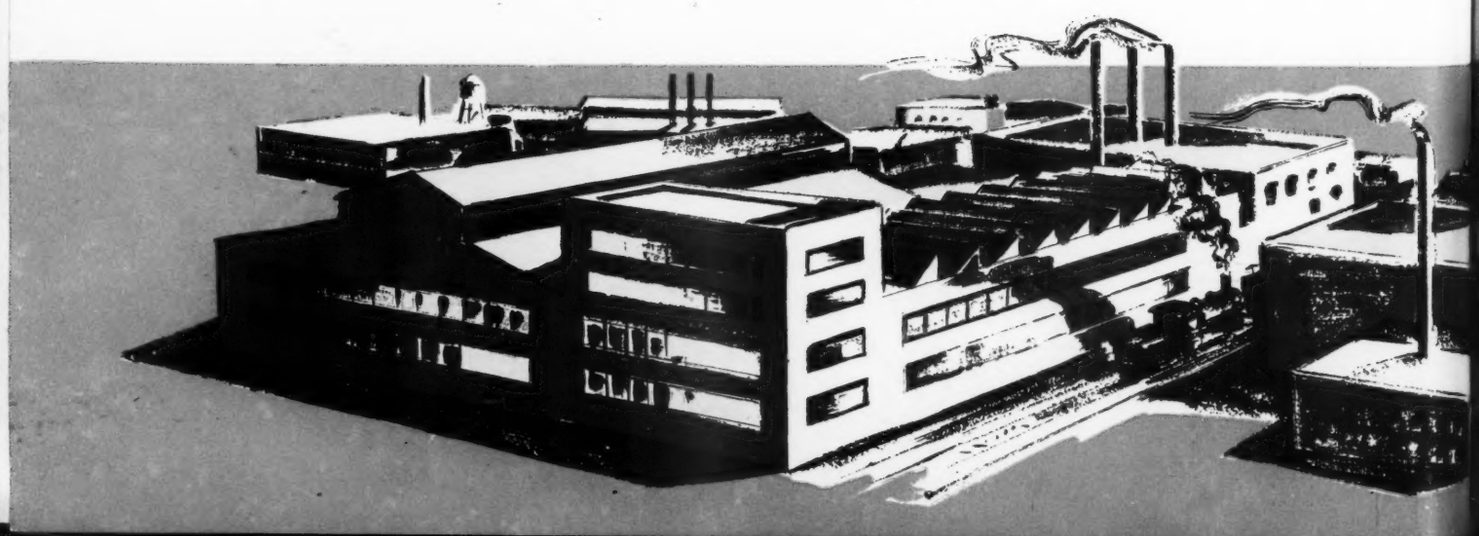
DURING the past 15 years Everdur* has won for itself a high regard as the ideal metal for many tough industrial applications. Its unusual resistance to corrosion, its superior welding properties, and tensile strength comparable to mild steel, have led to its use in industries of every character.

Today, these same advantages have made Everdur essential to the Nation's program of defense . . . And, as you'd imagine, Everdur has enlisted for Uncle Sam on land, on sea and in the air in many varied ways . . . a few of which are mentioned in the paragraphs accompanying these illustrations.

Because the adaptability of Everdur has led to such widespread usefulness in the defense program, the ever-quickening tempo of armament production means a corresponding step-up in the demand for this unique alloy.

Needless to say, we are steadily increasing the production of Everdur Metal. Though it may not now be possible to obtain sufficient supplies for all commercial or non-defense requirements, one thing is clear: "Everdur" will come to be a name grown stronger with a Nation's strength—and in the peace-time future this group of copper-silicon alloys will find even wider fields of application.

THE AMERICAN BRASS COMPANY • General Offices: Waterbury, Conn.



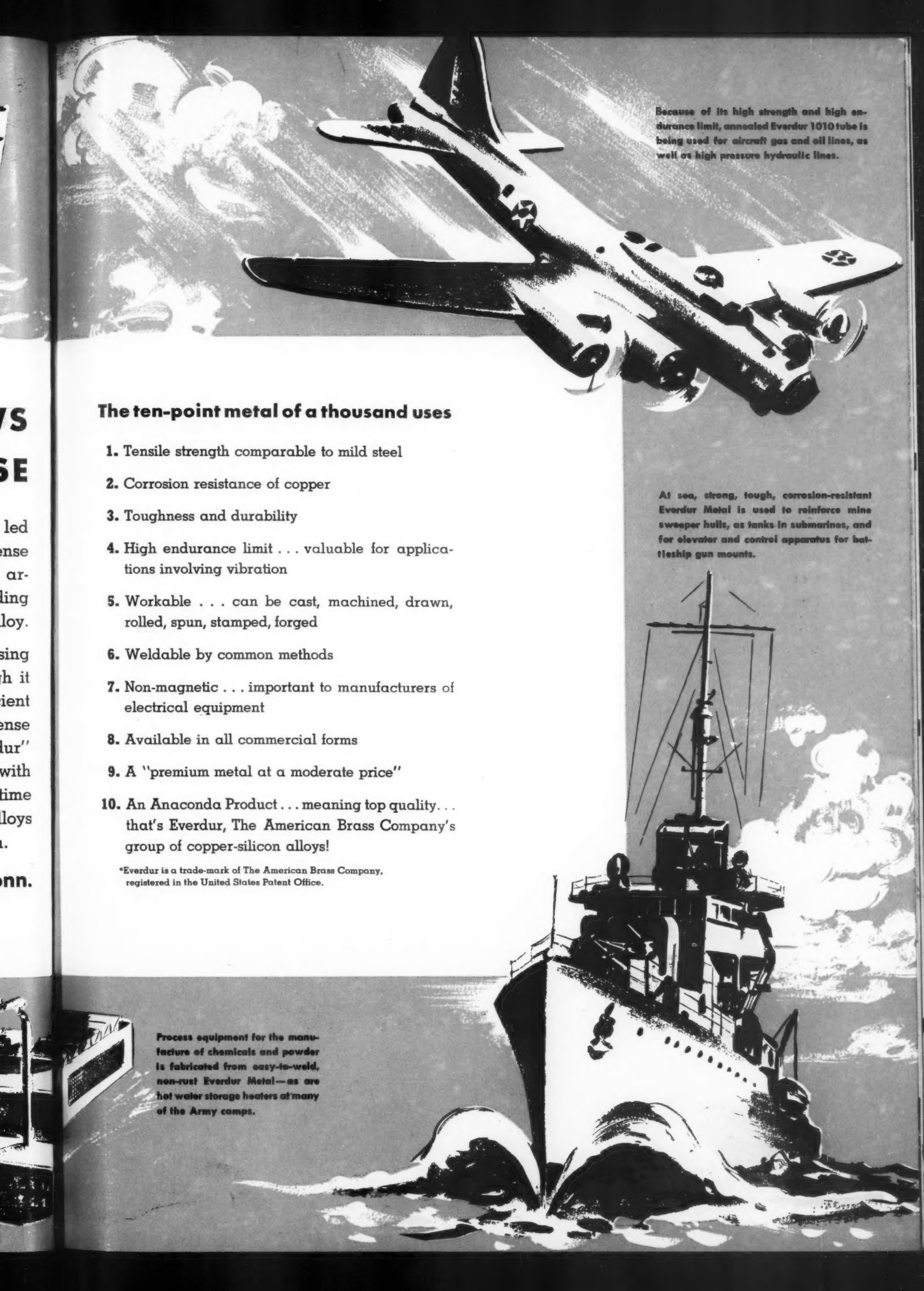
Because of its high strength and high endurance limit, annealed Everdur 1010 tube is being used for aircraft gas and oil lines, as well as high pressure hydraulic lines.

The ten-point metal of a thousand uses

1. Tensile strength comparable to mild steel
2. Corrosion resistance of copper
3. Toughness and durability
4. High endurance limit . . . valuable for applications involving vibration
5. Workable . . . can be cast, machined, drawn, rolled, spun, stamped, forged
6. Weldable by common methods
7. Non-magnetic . . . important to manufacturers of electrical equipment
8. Available in all commercial forms
9. A "premium metal at a moderate price"
10. An Anaconda Product . . . meaning top quality. . . that's Everdur, The American Brass Company's group of copper-silicon alloys!

*Everdur is a trade-mark of The American Brass Company, registered in the United States Patent Office.

At sea, strong, tough, corrosion-resistant Everdur Metal is used to reinforce mine sweeper hulls, as tanks in submarines, and for elevator and control apparatus for battleship gun mounts.



Process equipment for the manufacture of chemicals and powder is fabricated from easy-to-weld, non-rust Everdur Metal—as are hot water storage heaters at many of the Army camps.

Research which developed *Everdur* offers many other Copper-Base Alloys

The Research Department of The American Brass Company has developed many of the copper-base alloys now in common use for special types of service. In addition, this research today is devoted to furthering the usefulness of Anaconda Metals to the defense program. The Technical Department of this Company is prepared to cooperate in determining the one best metal for a specific application and the correct procedure for its fabrication.

PRINCIPAL PRODUCTS

COPPER, BRASS, BRONZE AND NICKEL SILVER — SHEETS, WIRE, RODS, TUBES

Beryllium Copper	Condenser Tubes	Everdur Tank Plates	Phosphor Bronze
Brass Pipe	Copper Tubes	Extruded Shapes	Pressure Die Castings
Brazing Solder	Copper Tube Fittings	Eyelets, Grommets, etc.	Hot Pressed Parts
Bronze Screen Wire	Drawn Sections	Flexible Metal Hose	Tobin Bronze Shafting
Bus Bars and Shapes	Electrical Conduit	Free Cutting Brass Rods	Welding Rods

ANACONDA
from mine to consumer

THE AMERICAN BRASS COMPANY

General Offices: Waterbury, Connecticut • Subsidiary of Anaconda Copper Mining Company

MANUFACTURING PLANTS—Ansonia, Conn. • Buffalo, N. Y. • Detroit, Mich. • Kenosha, Wis. • Torrington, Conn Waterbury, Conn.

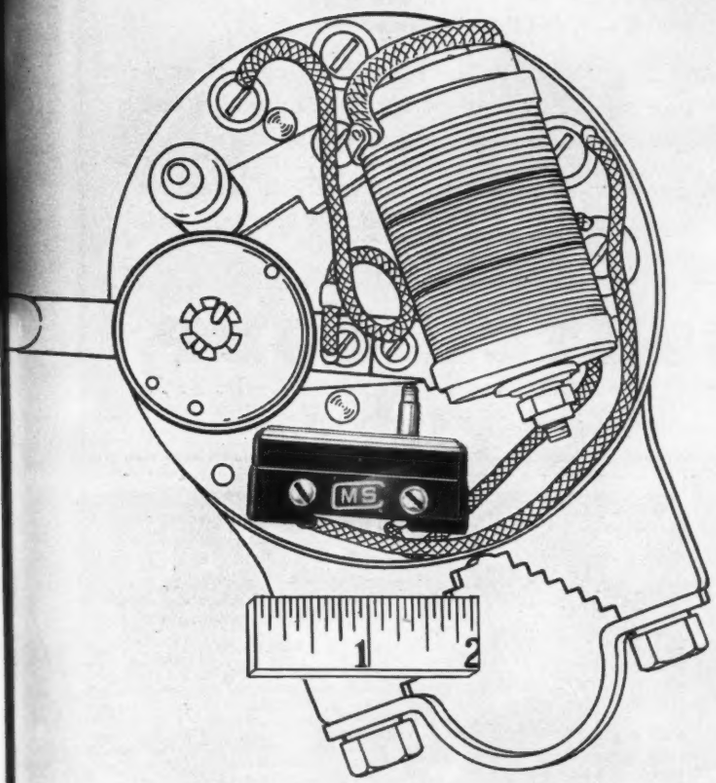
OFFICES AND AGENCIES—Atlanta, Ga. • Boston, Mass. • Buffalo, N. Y. • Chicago, Ill. • Cincinnati, Ohio • Cleveland, Ohio Denver, Colo. • Detroit, Mich. • Houston, Texas • Kenosha, Wis. • Los Angeles, Calif. • Milwaukee, Wis. • Minneapolis, Minn. Newark, N. J. • New York, N. Y. • Philadelphia, Pa. • Pittsburgh, Pa. • Providence, R. I. • Rochester, N. Y. • St. Louis, Mo. San Francisco, Calif. • Seattle, Wash. • Syracuse, N. Y. • Washington, D. C. • Waterbury, Conn.

WAREHOUSES: Chicago, Ill. • Cleveland, Ohio • Milwaukee, Wis. • Philadelphia, Pa. • Providence, R. I.

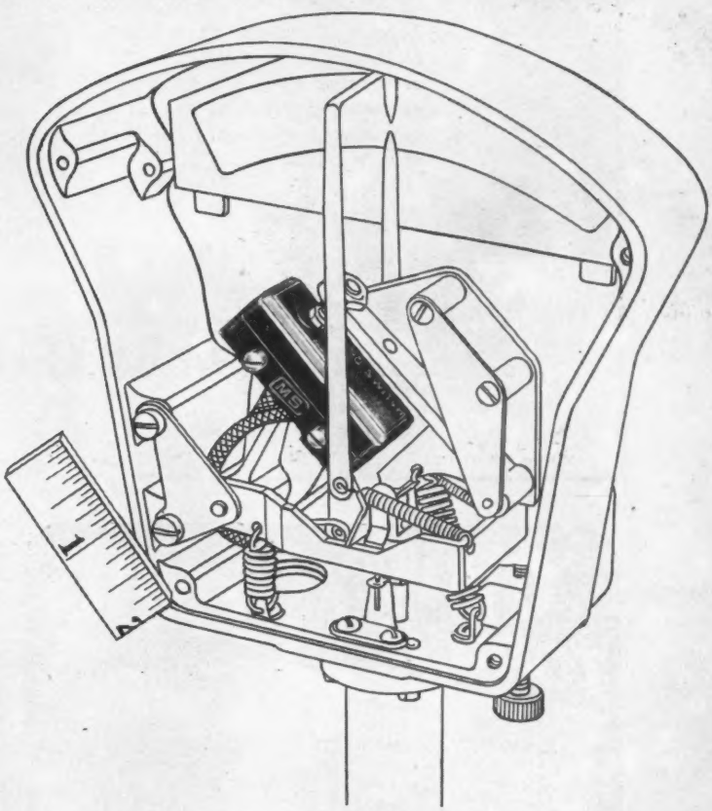
IN CANADA: Anaconda American Brass Limited. Manufacturing Plant and General Office, New Toronto, Ontario Montreal Office: 939 Dominion Square Building

MICRO SWITCHES
Insure Precision Operation
In These Compact Designs

Empire Electric Brake Company, Newark, New Jersey, and the Sarco Company, Inc., New York City, both use Micro Switches because of their precise operation, absolute dependability, extremely long life, and small size which permits compact design.



In the Magdraulic Electric Brake manufactured by the Empire Electric Brake Company, Newark, New Jersey, the Micro Switch is an important part of an efficient, safe, electrical brake system for trucks and trailers. When the lever of this control is operated it releases the pressure on a spring plunger Micro Switch and lights the tail light on the truck or trailer. The switch used in this manufacturer's product is Type R-RS, fully described on Page 1.05, Micro Switch Catalog No. 60.



In its Type LS1 Temperature Control, the Sarco Company, Inc. of New York, combines accurate indication with automatic control by means of a Micro Switch which is actuated at any desired temperature. Various types of Micro Switches are used depending on the type of circuit to be controlled. These switches may be the Type R-R, G-R or B-R, complete description and details of which will be found on Page 1.03 of the new Micro Switch Catalog No. 60.

● It makes little difference where you look in industry, you will find the Micro Switch being employed in countless ways and on numberless products.

If space is at a premium in your product, if very precise action is essential, if small movement and small energy are vital, if absolute dependability is a "must," and millions of operations a definite requirement, you will find a Micro Switch performs better and more economically than any method you can devise for your particular purpose.

The basic Micro Switch is very small—no larger than your thumb. It measures only 11/16″ x 27/32″ x 1-15/16″ in size, weighs only an ounce, operates on pressures as low as 1¼ ounces and movements as low as .0002″.

This remarkable little switch is listed by the Underwriters' Laboratories with ratings of 1200 V. A. loads, from 125 to 600 Volts A.C. It can be supplied in a wide range of housings that will withstand every operating shock; in lightweight aluminum housings for aircraft, in a sealed housing that is oil, water, and dust-tight and in an explosion-proof housing. There are actuators specifically designed for specific actuation. If your design calls for precision switching it might be well for you to seek the advice of Micro Switch engineers who are highly skilled in the solution of problems involving precision switching.

The new Micro Switch Catalog No. 60 is more than a catalog. It is a complete handbook designed to help you apply precise snap action switches to your design. Your engineers should have a copy. Send us a request.

Copyright 1941, Micro Switch Corporation

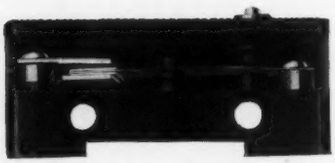
Micro Switch is a trade name indicating manufacture by Micro Switch Corporation.

MICRO MS SWITCH

Manufactured in FREEPORT, Illinois, by Micro Switch Corporation. Sales Offices: New York, Chicago, Boston

Sound Simplicity . . .

Is a Basic Characteristic of Mu-Switch



This Simple Switch . . .

handles 15 amperes non-inductive load at 115 volts A.C. or ½ H.P. at voltages up to 460 A.C. under operating pressure as low as 4 ounces with movement differential of only 1/1000".*

That's why design engineers prefer this compact switch for applications that require sure performance. They appreciate the extra strength and dependability provided by its freedom from complex lever systems, compoundings and multiplicity of parts.

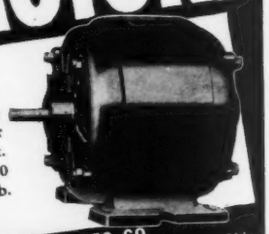
And they recognize the essentially correct engineering of its one-piece spring snap action and its reverse, cross-center movement.

A free sample Mu-Switch, cut away to reveal its basic simplicity of design and construction, will gladly be sent on request.

★ D.C. model handling 2 K.W. without condenser also available. Write for new 1942 catalog.

MU-SWITCH CORP.
CANTON • MASSACHUSETTS • U. S. A.

OHIO TORQUE MOTORS

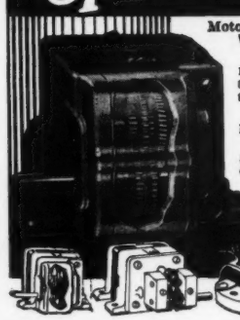


● Will rotate slowly or stand stalled exerting full torque without overheating for any time cycle. Ball bearing and quiet operating. Built for multiple or single phase a.c., and for direct current. Sizes to exert torque from 1 oz. ft. to 100 oz. ft. equal to 1/16 ft. lb. to 6¼ ft. lb.

WHAT IS YOUR PROBLEM?

THE OHIO ELECTRIC MFG. CO.
5911 Maurice Avenue, Cleveland, Ohio

SpeedWay Worm Drive Back Geared FLEA POWER MOTORS 110 VOLT AC, DC, or Universal



Motorize products, make them Automatic with Speed-Way Motors.

Dependable 110V Miniature Motors . . . to your requirements . . . A.C., D.C., or Universal. Case or skeleton types, with or without back gears . . . any speed or torque. Hundreds of thousands in use.

Low Cost . . . produced in volume by modern production methods. . . . surprisingly inexpensive.

Technical Service . . . state your problems, we'll answer with prices, specifications, and possible delivery dates. Any Quantity . . . 1 or 1,000,000.

Write for Motor Sheets

SPEEDWAY MFG. CO
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BI-METAL BLANKS, SHAPES OR SUB-ASSEMBLIES

Write Naming Your Product for Specific Application Data

By DOLE NON-FATIGUING ECONOMICAL *Backed Up By Able Engineering Co-Operation*

THE DOLE VALVE COMPANY
1901-1941 CARROLL AVENUE
Chicago, Illinois

IN DESTRUCTIVE ATMOSPHERES
Protect Your Production Line With

Century Totally Enclosed Fan Cooled Motors

They are designed to safeguard the motor from the destructive effects of air that is fogged with metal cutting oils, or atmospheres containing abnormal quantities of metallic, abrasive, or other dusts—conditions that might ultimately destroy the insulation or clog the windings of a general purpose open motor.

The fan inside the pressed steel fan housing produces a blast of air flowing between the cast iron frame and the laminations, that not only cools the motor but also keeps the large air passages clean.

The modern, streamlined appearance of these new motors matches the trend of present day equipment design—they are easy to clean outside.

If atmospheric conditions are a problem in your plant, consult your nearest Century Motor Specialist. His experience with similar problems may well save you time and money — and help to keep production rolling during these critical, high pressure days.

CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis, Mo.
Offices and Stock Points in Principal Cities

One of the Largest Exclusive Motor and Generator Manufacturers in the World

Peerless

QUALITY MOTORS

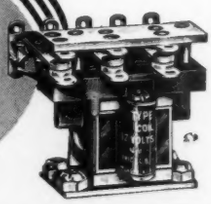
Peerless is equipped to handle large or small orders in standard or special designs.

Every facility of our organization is at your command providing you with full cooperation and prompt action. Our expert engineering service guarantees you maximum efficiency, rugged design and trouble-free operation. Peerless has been building better motors for the past 48 years—always maintaining a quality and a performance unexcelled by any other motor.

THE PEERLESS ELECTRIC CO., WARREN, OHIO

Remember!

DEFENSE DEMANDS QUALITY



Take no chances on relays for defense products—or for regular products. There is no substitute for quality.

The new Type "J" Relay is designed to surpass. Engineered to meet severe requirements, it provides an even greater operating margin for normal uses.

Write for Bulletin No. 612

THE NEW G-M RELAY TYPE "J"

The Type "J" Relay is small, compact, with extra power for such small size. 2 Pole or 3 Pole. Contacts have self-cleaning "wiping" action. Relay designed to meet aircraft requirements as to humidity, temperature, and vibration tests.

DEPEND ON . . . G-M

G-M LABORATORIES INC.
4309 NORTH KNOX AVE. CHICAGO, U. S. A.

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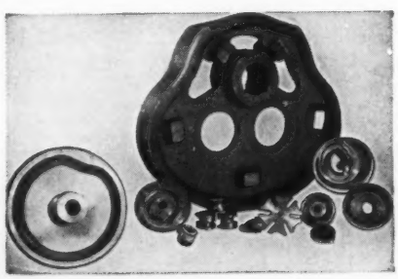
ALL STYLES ANY SIZE UP TO 50" DIA.
CAMS ALSO GENEVA MOTIONS
SEND BLUE PRINTS FOR PRICES



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Instead of making guns or shells "Esco" has stepped up production of special motors, motor-generators and converters over ten times.

"Esco" is doing an "All Out" job for National Defense.

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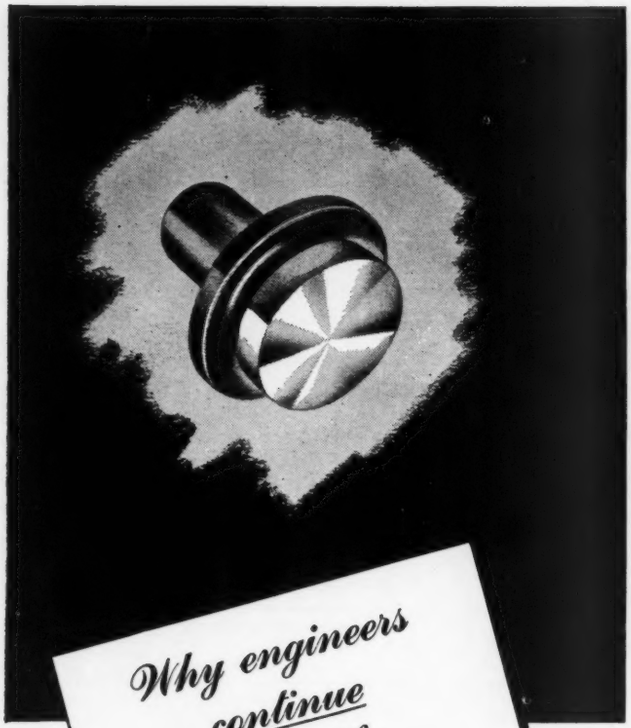

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The same precise *uniformity* characterizes every Callite contact, whether you use one or one million, today or next month. This precision engineering, lightening the burden of today's responsibility, wins and *holds* engineers' confidence in Callite.

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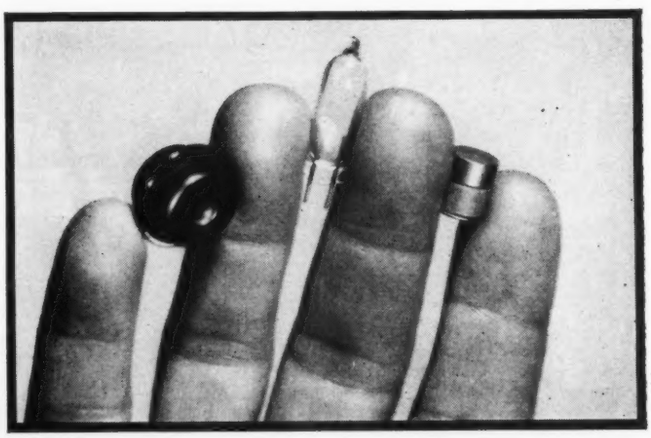
FAMILIARITY with General Electric's three-way line of small-size Kon-nec-tors helps designers of electrical equipment give customers products that provide long, satisfactory service at low cost. For these modern mercury contact devices, although inexpensive, may be operated millions of times with unvarying efficiency, no flashing, and no sparking. They include:



1 **THE NEW "BUTTON" TYPE** Kon-nec-tor, designed originally as a silent-operating wall switch, and adaptable to many types of use because of its unique compact size.

2 **THE LOW-PRICE GLASS** Kon-nec-tor of the single-pole, single-throw type with a mercury-to-metal contact. The Kon-nec-tor can handle loads up to 5 amperes.

3 **THE "PELLET" TYPE** of mercury contact, although only 3/8″ in diameter and 7/16″ long, has a 30-watt capacity on 12-16 volts at 3 amperes. Has a multitude of uses.

For further information about these low-cost G-E Kon-nec-tors, write or wire the address given below.

NELA SPECIALTY DIVISION, LAMP DEPT.
GENERAL ELECTRIC
410 EIGHTH STREET, HOBOKEN, N. J.

F-M MOTORS WITH THE COPPERSPUN ROTOR . . .

● *Now* is the time to give your motors a thorough physical examination. Can they be depended upon to stand up under today's greater demands? Find out *before* they fail . . . *before* they cause expensive delays.

Then *compare* your motors with Fairbanks-Morse Motors having the *Copperspun* rotor. These F-M motors set a new standard of performance . . . a standard that's in tune with today's production tempo.

They are unrivaled in ability to stand up under the most severe plugging and reversing service. Why? Because they are the *only* motors having rotors with windings centrifugally cast in one piece of SOLID COPPER.

And the characteristics of copper make it the ideal rotor material. Copper has high electrical and thermal conductivity (twice as good as aluminum), greater strength, and low thermal expansion.

If dependable power is important to your operations, investigate these superior motors now. Write Fairbanks-Morse & Co., Dept. L-202, 600 S. Michigan Ave., Chicago, Ill.

Branches and service stations throughout the United States and Canada.

Copperspun
Patented

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DIESEL ENGINES ELECTRICAL MACHINERY RAILROAD EQUIPMENT WASHERS-IRONERS STOKERS
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from the Original by Allen Houser, Grandson of Geronimo

Sabotaged . . .

by Old Style Methods!

★ Stopped dead by primitive means . . . crude methods are a charge in peace—in war a weak defense!

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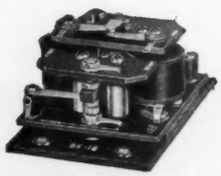
Modern as tomorrow's airplane—Relays by Guardian must be up-to-the-minute because they're specified on the planes of tomorrow as well as today's Trainers—Fighters—Bombers—Tanks—for Transmitters—Turrets—Bombing Equipment—Fire Control—or practically every defense job you figure.

Do you need Gun Switch Handles—Turret Controls—Relays that weigh less than ½ ounce—Double Pole, Double Throw Control (Thumb-size, one-ounce weight)—Solenoids—or a two-pound Contactor to handle 1000 amp. surges?

WITH A TWO-YEAR START—GUARDIAN IS READY WITH TODAY'S DEFENSE CONTROLS—GOVERNMENT APPROVED!

Planning for TOMORROW—there's a good chance we have your 194? control on the shelf right now! When the end of defense calls for increased sales in strongly competitive peacetime markets, volume will only come if you're ready to offer the most *fully automatic* equipment you can design TODAY.

Perhaps you've already begun. If so, we can help you. If not, a letter, blueprint or a visit to our plant will give you a big head-start on the field.



Series BK—16 Relay. Built to minimum tolerances and the most exacting requirements in production quantities for the U. S. Signal Corps.

FREE—*Initial Your Letterhead for Catalog "P". Write*

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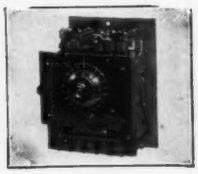
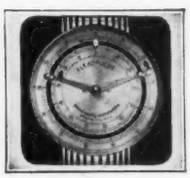
LARGEST LINE OF RELAYS SERVING AMERICAN INDUSTRY





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LUBRICATION • LIQUID TRANSFER

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"CAN'T BEAT TUTHILL SMALL PUMPS FOR INDUSTRIAL SERVICE"

Whether you are considering a design which includes coolant, hydraulic operation, lubrication or liquid transfer, it will pay you to get the facts about Tuthill precision-built pumps. They are engineered for the job and can be furnished in various capacities from 1 to 200 gallons per minute at pressures up to 350 psi.

If the drive shaft reverses, Tuthill's automatic reversing pump provides the answer because it delivers from the same port regardless of shaft rotation.

Automatic pressure releasing feature is included in the Tuthill Model M coolant pumps. This permits the escape of chips or foreign matter without injury to working parts, and also compensates for wear.

Tuthill provides stripped model pumps for direct incorporation into the design of any machine. All Tuthill pumps have a reputation for uniform quality, dependability and long life performance, backed by hundreds of thousands in use today.

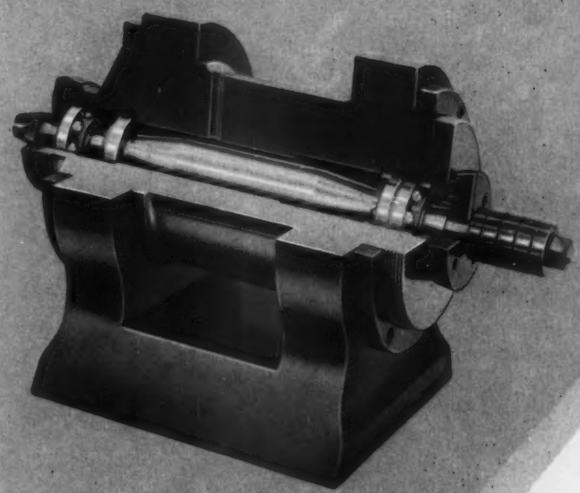
GENERAL CATALOG AVAILABLE ON REQUEST

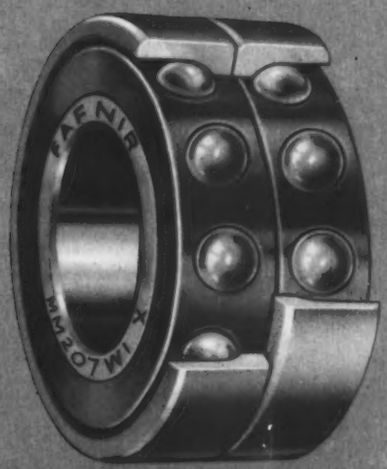
TUTHILL PUMPS

TUTHILL PUMP COMPANY, 941 EAST 95th ST., CHICAGO, ILLINOIS

You'll have to Split an Inch into Millionths

TO MEASURE THIS SHAFT'S DEFLECTION

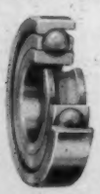




As this shaft turns up 40,000 r.p.m. you can put your thumbnail against it and not feel motion. It will take the most sensitive of measuring devices to detect in it any deflection whatsoever — for it's mounted on two Fafnir Preloaded Pairs of X Type Extreme Precision Spindle Bearings.

Shaft rigidity like this — *lasting* through hundreds and thousands of operating hours on industry's high-precision tools — speaks in terms that a production man can understand: Finest possible finish at lowest possible cost. The Fafnir Bearing Company, New Britain, Connecticut.

MM200WI SERIES



Standard dimensions, precision tolerances.

MM9500 SERIES

Large-bore compact for close spacing of larger 20,000 to 30,000 r.p.m. spindles.

MM200WIX SERIES

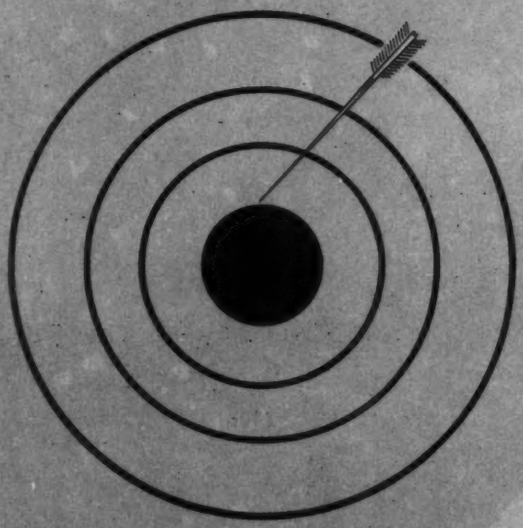
Extreme-precision, preloaded duplex pairs, for internal grinding up to 40,000 r.p.m. and more.

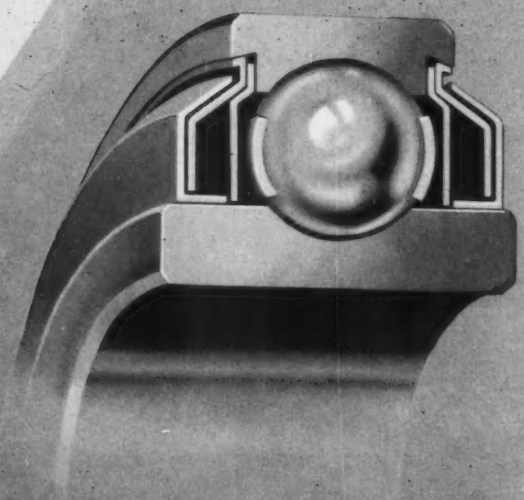
FAFNIR
Ball Bearings

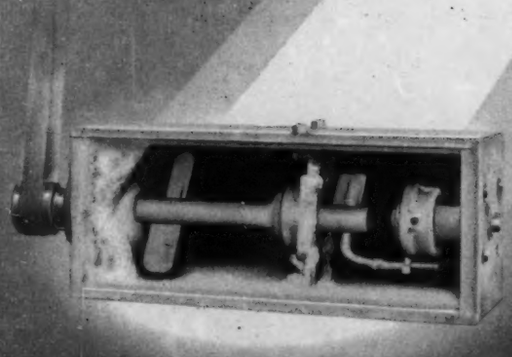
THE BALANCED LINE
MOST COMPLETE IN AMERICA

THE MISS that Beats a Bull's-Eye

WHEN DIRT MUST BE KEPT OUT OF BEARINGS







The old-fashioned bearing seal made a "bull's-eye" every time. Composed of felt or other rubbing material, it hit the shaft or bearing inner ring, and bore against it squarely during every turn.

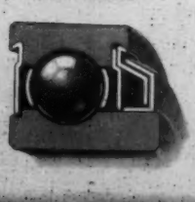
In the new "Mechani-Seal" Ball Bearing, Fafnir has engineered a "miss" that beats the old-fashioned "bull's-eye". For the integral steel plate shield and revolving slinger of this 100% efficient sealed bearing never touch the shaft at all, to set up friction and drag. They miss, but by tolerances so extremely close that dirt and grease do not pass.

The result is the most efficient sealed bearing you ever used, with a bonus of friction-freedom that makes the Fafnir "Mechani-Seal" outstanding. The Fafnir Bearing Company, New Britain, Connecticut.

TYPE L
Single Seal

TYPE G-LDB
Seal and Shield Combination with provision for relubrication and alignment.

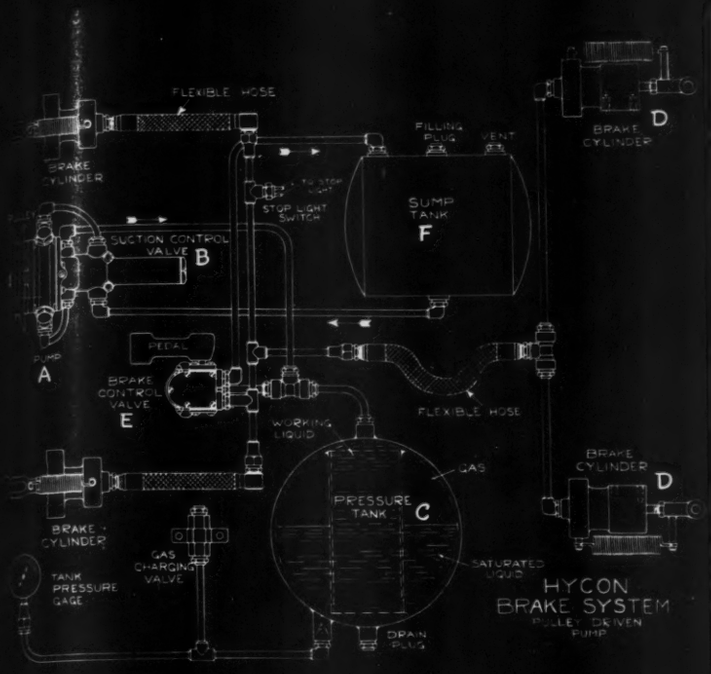
TYPE LD
Seal and Shield Combination



TYPE G-LLB
Double Seal with provision for relubrication and alignment.

FAFNIR
Ball Bearings

THE BALANCED LINE
MOST COMPLETE IN AMERICA



Typical installation with Hycon pump and pressure tank actuating 4 work cylinders

The diagram shows a typical assembly of HYCON equipment. The work cylinders (D) may serve any desired function such as the movement of a brake, clutch lever, door, electric circuit breaker. To these, hydraulic pressure is applied in any amount up to the designated limit by the control valve (E). The energy for actuating the work cylinders is primarily derived from the pressure tank (C) and this in turn is charged by the pump (A). The delivery from the pump is governed by the suction control valve (B). The work cylinders on the return stroke discharge into the sump tank (F) from which the fluid is pumped into the pressure tank and/or the work line.

HYCON

lends itself to many uses— here are just a few

Hycon operates the steering and braking mechanisms of heavy vehicles including road, marine, air transport and track-laying tanks. It regulates speed and pressure in straight-line-movement mechanisms such as machine tools, processing and printing machinery, foundry and mill apparatus, and doors of all kinds . . . replaces electric solenoids and low pressure compressed air engines . . . tests high pressure hose, lines and hydraulic devices . . . and provides for high pressure lubrication of thrust bearings and the support of heavy loads.

An invitation to engineers and executives

Before you next design the control or control-actuating system of any mechanism employing straight line motion, get the facts on Hycon.

Hycon can probably help you to achieve new operating efficiencies, new compactness of design, new accuracy of control, and increased machine capacity at lower costs.

Many of the reasons why are implicit in the booklet recently prepared by Hycon and entitled, "Recent Developments in Systems for Hydraulic Control of Straight Line Motion". A copy is being held for you. Please let us know where to send it.

What are you looking for in control and control-actuating mechanisms?

PERFORMANCE?

Hycon gives you pressures up to 3000 psi in so controllable a form that you can literally split a drop of working fluid under several thousand pounds. Moreover, Hycon is always ready for action, intermittent or continuous . . . ready with power drafts far in excess of the pump's capacity and independent of its operation—and with a supply of power for you to tap when the prime power source fails.

ECONOMY?

Hycon is light, compact, and economical in cost. It eliminates the need for constant pumping on applications requiring intermittent operation and, within its working range, provides one of the highest ratios of power output to power input known in practical hydraulics. On one typical installation for example (the operation of a traffic fin) as much as 100 hp is supplied for fifteen seconds by the Hycon pressure storage tank and is replaced in 25 minutes by a 1 hp motor operating in connection with a Hycon pump.

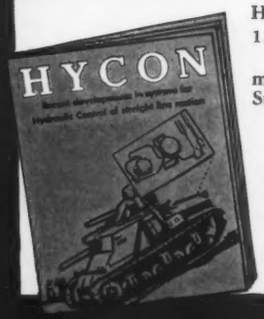
DEPENDABILITY?

Hycon operates efficiently and without adjustment under all ordinary temperature conditions . . . is designed to eliminate such trouble breeders as gaskets, stuffing boxes and packing, non-metallic diaphragms and pipe threads . . . and operates so all moving parts are submerged in lubricant, and rubbing surfaces are hardened by nitriding or equivalent process.

HYDRAULIC CONTROLS, INC.

Division of The New York Air Brake Company

Dept. 107, 122 South Michigan Avenue, Chicago, Ill.



Hydraulic Controls, Inc., Dept. 107
122 South Michigan Avenue, Chicago, Ill.

Please send me my copy of "Recent Developments in Systems for Hydraulic Control of Straight Line Motion" to:

Name.....

Company.....

Street Address.....

City.....*State*.....

The DISTRIBUTOR STANDS IN THE MIDDLE

. . . *but he is no mere middleman*

Speaking from 30 years' experience in selling only through the Distributor, The Allen Company affirms these facts to all who may be in doubt:

THE INDUSTRIAL DISTRIBUTOR IS NO MERE MIDDLEMAN.

HE IS THE LOCAL WAREHOUSER of the manufacturing supplier . . . BUT HE IS ALSO THE PROCUREMENT AGENT of his customer, the manufacturing consumer.

FROM SCATTERED SOURCES he brings together specialized stocks, selected with foresight and knowledge of his customers' requirements.

HE ADAPTS AVAILABLE SUPPLIES to his customers' needs, and adapts the customers' needs to the supply by technical advice in equipment change-overs or simplification.

HE TAPS NOT ONLY REGULAR supply-sources, but often has an "inside line" on surplus tools, supplies and machines in other plants or stocks unknown to defense buyers.

HE PLANS TO FORESTALL any shortages or delays that would vitally affect plant operations.

BEING A BRINGER-TOGETHER of supply and demand, he serves as a short-cut to the procurement of every essential item whether in or out of his inventory.

HE KNOWS NO HOURS short of 24-hour delivery schedules. He accepts emergencies as the measure of his usefulness. His indefatigable purpose is to keep wheels turning.

HE IS RECOGNIZED AND RELIED UPON as the buyer's first aid and last resource.

HE IS NEEDED in exact proportion to the pressure of unfilled wants on Industry's order-list.

THE ALLEN MANUFACTURING COMPANY, HARTFORD, CONN., U.S.A.

THE NEW Dayton V-BELT

WITH PATENTED FLAT COG CONSTRUCTION

TESTS PROVE: 21% GREATER PULLING POWER 22% LONGER LIFE

Yes, it's the *extra value* V-Belt . . . it's the V-Belt with patented flat cog construction that's built for both V-to-V Drives and V-Flat Drives! Only this new V-Belt has Dayton's non-skid tire tread design to increase traction and pulling power on *flat* pulleys, PLUS Dayton's die-cut raw edges for a more powerful grip on *grooved* pulleys.

And that isn't all. Only this new Dayton V-Belt has the stronger, heat-resistant Daytex Cord in the neutral axis section—and Dayton's "Built-to-Bend" construction—exclusive features which mean that Daytons run cooler and last longer under the strain of constant high-speed flexing.

Tests prove that this revolutionary V-Belt on flat pulleys of a V-Flat Drive has more than 21% greater pulling power—and laboratory and field tests show that on grooved pulleys this V-Belt has an overall increased life of at least 22%.

This new V-Belt, with its added performance and unmatched economy, is but another achievement in Dayton's 21 years of V-Belt pioneering. *Yet it costs no more!* Write for complete information and engineering data.

The Dayton Rubber
MANUFACTURING COMPANY, DAYTON, OHIO
The World's Largest Manufacturer of V-Belts
DAYTON, THE GREATEST NAME IN V-BELTS

BUILT-TO-BEND FEATURE AND DAYTEX CORD mean longer life under constant high-speed flexing.

FLAT COGS AND DIE-CUT SIDES provide greater gripping power on grooved pulleys and on flat pulleys.

CROSSWISE RIGIDITY prevents distortion—assures maximum efficiency and longer belt life.

Dayton
V-BELTS
WITH PATENTED COG CONSTRUCTION
THE SAME BELT FOR V-FLAT DRIVES FOR V-TO-V DRIVES

Copyright, 1941, The Dayton Rubber Mfg. Co.

revises work tolerances

• The anti-friction bearing on this roll grinder demands adjustment to *exact* tolerance. "Without the Laminum shim," the manufacturer explains, "it would be necessary to turn down the cast iron collar a precise amount." He merely peels off Laminum brass laminations! Shims cut to your order. Obtain stock shim materials for maintenance work from mill supply distributors.

Laminated Shim Company INCORPORATED
63 Union St., Glenbrook, Ct.

Write for file-folder of shim application photos, and Laminum sample.

1664

LAMINUM

THE SOLID SHIM THAT peels FOR ADJUSTMENT

SEND US YOUR SUB-CONTRACTS

THESE are times to pull together. Not too many plants are set up to produce Defense needs complete from start to finish. Springs and screw machine parts are vital to almost every Government item. Here we are more than glad to lend a hand.

Peck Service provides screw machine parts in all sizes up to 1¼", milled, drilled, slotted, tapped, threaded—and all varieties of springs up to ⅛" wire size. Extreme precision when necessary. Send us your blueprints for estimate.

PECK SPRINGS
AND SCREW MACHINE PARTS

The Peck Spring Co., 14 Summit St., Plainville, Conn.

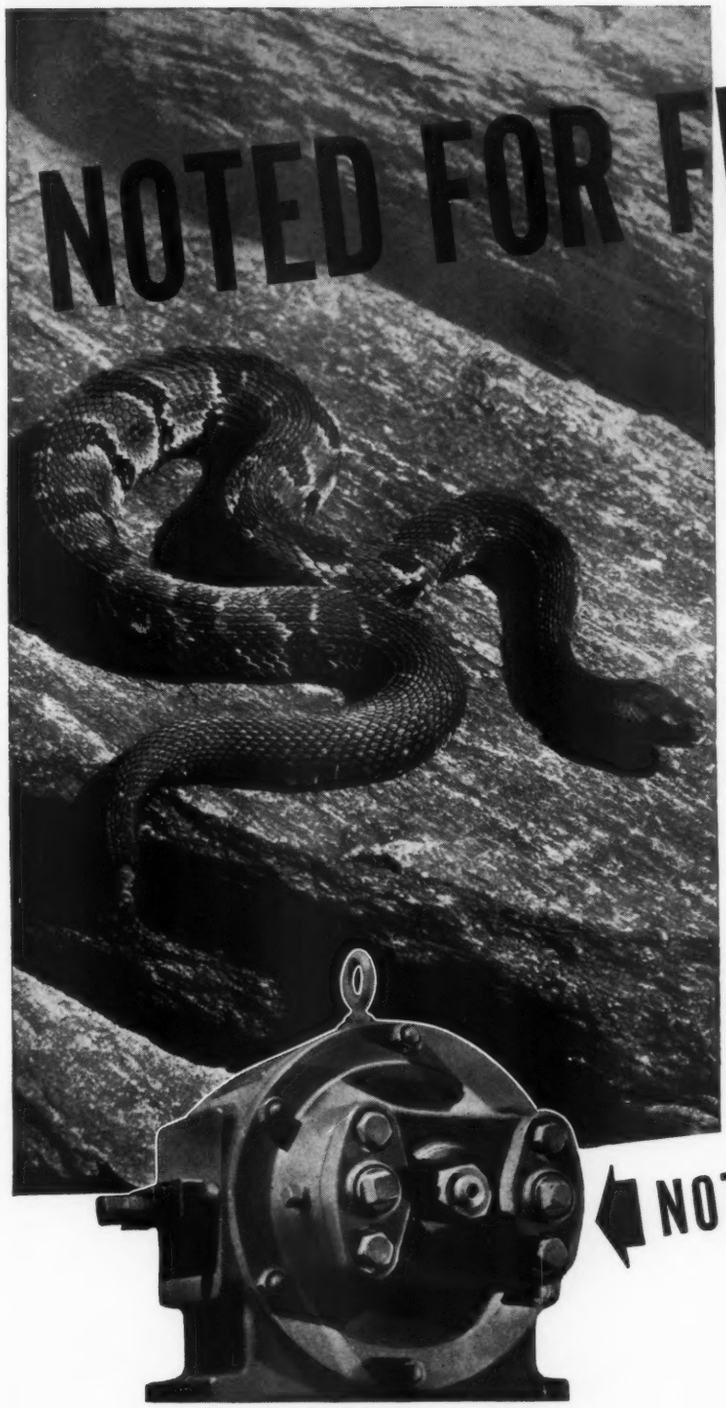
WE'RE TACKLING OUR JOB THE "*Progressive*" WAY

As manufacturers of special headed and threaded metal fastenings — so urgently needed in holding together the implements of war and the machines and tools that make them — our first obligation is to serve the interests of the defense program.

But in spite of an avalanche of orders that must be given preference because of priority ratings, we again say to our regular civilian customers, "We do not forget our obligations to you." By stepping-up man hours, by installing new machinery, by squeezing the utmost out of every hour of every day, PROGRESSIVE is striving to make deliveries in response not merely to war demands but to the call of non-defense industry as well.

QUALITY PROMCO BRAND

The PROGRESSIVE MFG. CO.
TORRINGTON · · · CONNECTICUT



NOTED FOR FLEXIBILITY

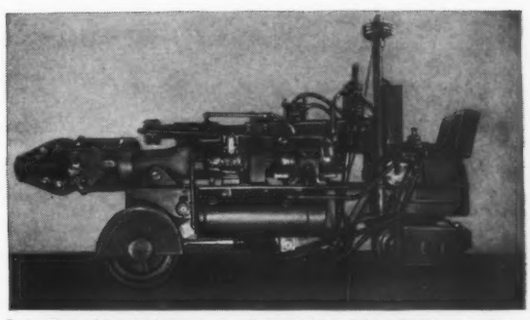
There never was a time when the flexibility in application of Fluid Power, (oil under pressure) meant so much to you. Hele-Shaw Fluid Power is fluid pressure—pressure to operate presses, rams, and reciprocating devices, but how it differs from mechanical drives! Snake-like, it can go anywhere, for Fluid Power is transmitted merely by means of pipes. Obviously this flexibility eliminates the necessity for "designing-in" a Hele-Shaw Fluid Power pump, since you can place the pump wherever it is convenient to do so, on or adjacent to the machine. Free yourself from drive design problems, speed up design with Hele-Shaw Fluid Power. Send for catalog explaining the many other design and operating advantages of Fluid Power today.

NOTE IT FOR FLEXIBILITY

THE

Hele-Shaw

Fluid Power Pump



Auto Floor Manipulator, manufactured by Edgar E. Brosius, Inc., Pittsburgh, Pa. The flexibility of Fluid Power makes it possible to locate the Hele-Shaw Pump at a convenient place upon the machine.

OTHER A-E-CO PRODUCTS: LO-HED HOISTS, TAYLOR STOKERS, MARINE DECK AUXILIARIES

AMERICAN ENGINEERING COMPANY

2501 ARAMINGO AVENUE, PHILADELPHIA, PA.

A 15-TON "KISS"

MEASURED IN THOUSANDTHS OF AN INCH!

HydrOILics finds the spot to straighten and how much to straighten it — and does the straightening — with precision and perfect hair-line control.

Straightening short, hardened steel automotive shafts to correct irregularities of a few ***thousandths*** of an inch is a delicate job—and a tough one! But HydrOILics does it with ease!

A standard type HydrOILic Straightening Press was equipped with gauges calibrated in thousandths of an inch. With the ram of the press raised and the shaft fixed between special centers, the gauges are moved along the shaft until they indicate where straightening is needed. Then the press ram operated by the control lever, is advanced to the shaft and the centers are lowered with the shaft to the straightening block. Additional movement of the control lever applies tonnage that straightens the shaft.

The gauges measure the shaft quickly—***after*** tonnage has been applied and ***before*** the shaft is released. Feather-light pressure on the operating controls the ram, which applies tonnage in direct proportion to the movement of the lever.

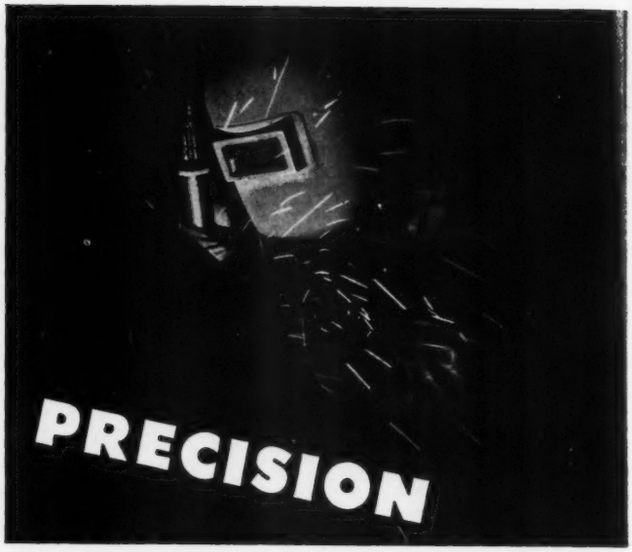
And this press, which is readily adaptable to many other operations, is only ***one*** example of the numerous ways HydrOILics is being applied to production jobs!

Because it is so amazingly versatile, Denison HydrOILic Equipment will give you the POWER, SPEED and CONTROL ***you*** want and need. It has solved many a knotty production problem for America's biggest industries, proving its efficiency on all types of jobs.

You'll want to consider HydrOILics for any production problem you may have. Consult us—or your Denison Representative—now! You will not be obligated, of course, and your inquiry will receive prompt attention. THE DENISON ENGINEERING COMPANY, 107 WEST CHESTNUT STREET, COLUMBUS, OHIO.

DENISON EQUIPMENT *in* APPLIED HydrOILics

TRADE-MARK



● You can take precision for granted where "Bayard" is concerned. Consult us on problems involving the design and manufacture of "special machinery".

- WELDED EQUIPMENT
- VALVES
- PRESSURE FITTINGS

ENGINEERS
M. L. BAYARD & CO.
INCORPORATED
MACHINISTS

PHILADELPHIA

"LOGAN"

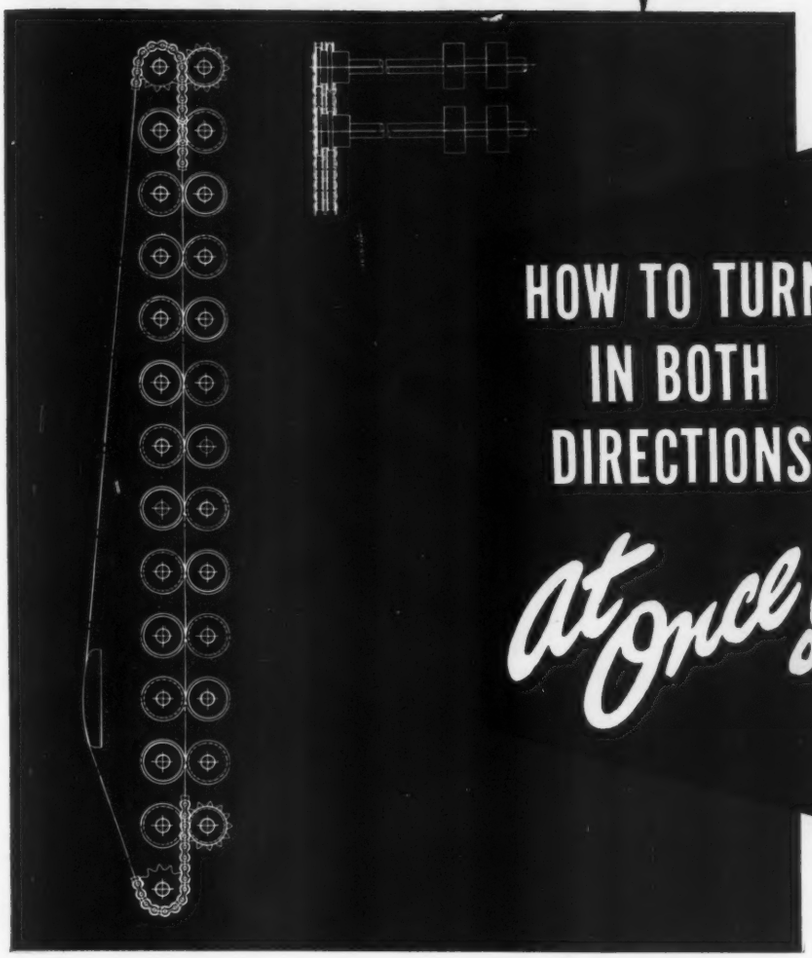
SURE FLOW CENTRIFUGAL PUMPS . . .

"LOGAN" Sure Flow Pumps are adaptable to an unusually wide range of service. They pump hot or cold liquids; and safely handle chips, filings, abrasives and most corrosive impurities. Model SFM 100, illustrated at right, is SELF PRIMING and can be mounted entirely away from the source of supply. No part of the pump need be submerged. No priming reservoir, foot valve or check valve is needed.

FLANGE MOUNTING FOR DIRECT INTAKE FROM SUPPLY TANK

Model SFM 300, illustrated at left, is designed for direct mounting on the side of the supply tank, or for installations when streamlining or lack of space prevent the use of an exposed intake line. Intake is direct through the flange base. The "LOGAN" Sure Flow Line is complete—10 sizes, 4 to 150 GPM . . . Write for Catalog No. 60 showing complete line and specifications.

LOGANSPORT MACHINE, INCORPORATED
912 Payson Road LOGANSPORT, INDIANA
Manufacturers of Air and Hydraulic Devices, Chucks Cylinders, Valves, Presses and Accessories



HOW TO TURN IN BOTH DIRECTIONS *at once!*

That's right! The designer of this label printing machine had to devise a method of revolving feeding rollers clockwise, and counterclockwise, in time and at the same time!

Please Note

Whether in relation to a defense problem or a commercial application, your inquiry will receive prompt attention. However, delivery of Baldwin products for the latter must be subordinate to the delivery of orders bearing priority distinction.

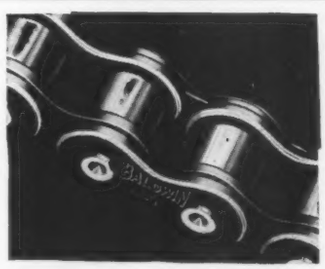
● Just imagine for a minute that you are the designer of this new label printing machine. You've been going "great guns" and then—

—at the feeding end you've arranged two vertical rows of shafts on which are mounted rubber friction rollers which grasp the labels and feed them to the press. Since these rows of rolls must revolve against each other, one line of shafts must run clockwise and the other counterclockwise. Space will not allow the use of two drives or idler sprockets. What to do?

Frankly we hope you do just what this engineer did—call the Baldwin man—and do it before you've wasted time and money in hunting for "special drives."

Here the Baldwin man suggested, in effect, a rack and pinion drive with an endless rack made up of simple, easily used roller chain belts.

Practically every driving, timing, and conveying system operates more successfully when it incorporates the basic advantages of roller chain belts. Have you a problem roller chain belts can solve? Call the Baldwin man now!



ONLY ROLLER CHAIN BELTS COMBINE

constantly efficient operation
with
indefinitely long life
with
shock-absorbing ability
with
resistance to dust and dirt
with
ability to operate on short centers

BALDWIN CHAIN BELTS

Please address your inquiry to:

BALDWIN-DUCKWORTH
Division of Chain Belt Company
321 Plainfield Street, Springfield, Mass.
Factories at Springfield and Worcester, Mass.

For Stable,

Superior in 7 Ways

- √ *Black* lines—*white* background.
- √ *Maximum* production.
- √ Uniform quality regardless of speed of development.
- √ Most *permanent* prints.
- √ No marking or discoloration.
- √ No deterioration of developing solution. No nightly wash-up.
- √ *Domestic* chemicals — a *dependable* source of supply.

Clear Black and White Prints

THE DIETZGEN

DIRECTO

TRADE MARK

DIRECT PROCESS

NOT only do Dietzgen Directo prints give you denser, blacker lines and clearer, whiter background, but they are more permanent than any print you have ever used. They retain their clear, strong contrast and sharpness for many months.

In addition, this different and *better* process assures uniform results no matter at what speed Dietzgen Directo prints are developed. Accidental variations in development speed do not penalize you. Print quality is *always* uniformly high.

There are other ways in which Dietzgen Directo prints save you time, "grief," worry and money.

The developer doesn't deteriorate. You can conveniently mix large quantities at a time—it won't spoil even in open containers. Every drop is usable. You never have to rebottle what's left in the machine at night or pour it down the drain. You simply add fresh developer as the old is used up. It won't harden in the machine, won't stain equipment, won't smear, smudge or discolor your prints.

More than that, the Directo developer is a DOMESTIC PRODUCT. A dependable source of chemical supply is assured. You can always count on the same quality of Dietzgen Directo prints. Finally, Dietzgen Directo paper is fast...it has more printing speed than your operator can use.

Directo offers you so many advantages you should find out at once what you are missing. Ask NOW for a *demonstration*...without cost, fuss or obligation. Write on your letterhead at once.

EUGENE DIETZGEN CO.

Chicago • New York • Pittsburgh • San Francisco • Milwaukee
Los Angeles • Philadelphia • Washington • New Orleans
Dealers in All Principal Cities

DIETZGEN

DIRECTO

THE *SUPERIOR*
BLACK AND WHITE DIRECT PRINT PROCE

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HIGGINS—More Power to Your Drawing • Pioneers in Art and Engineering have, for 60 years, relied on the smooth-flowing blackness of Higgins American India Inks to interpret their ideas. Higgins suits the finest pen, the most exacting drafting instrument as well as brush and airbrush. Drawing inks also available in complete color range. Ask your dealer for a color card.

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When You Specify

BARNES HYDRAULICS

• You buy more than equipment — you buy an engineered application. Designed and built for the job to be done.

As designers and builders of hydraulic units, panels, control valves, and pumps for manufacturers in a wide range of industries, we are in excellent position to solve your hydraulic problems and supply the necessary equipment.

And what's more — users of Barnes Hydraulics over a period of many years under most severe operating conditions report maintenance costs at an absolute minimum—lowest by comparison.

That's why careful buyers specify

BARNES HYDRAULICS

Send us your inquiries with information about the job to be done. We'll be glad to submit a proposal or if you say so, we will have an engineer call.

John S. Barnes Corporation

DETROIT SALES OFFICE
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MAIN OFFICE
AND FACTORY
ROCKFORD, ILL.

ADAPTABLE PUMPS

to Exactly

Fit Your Job

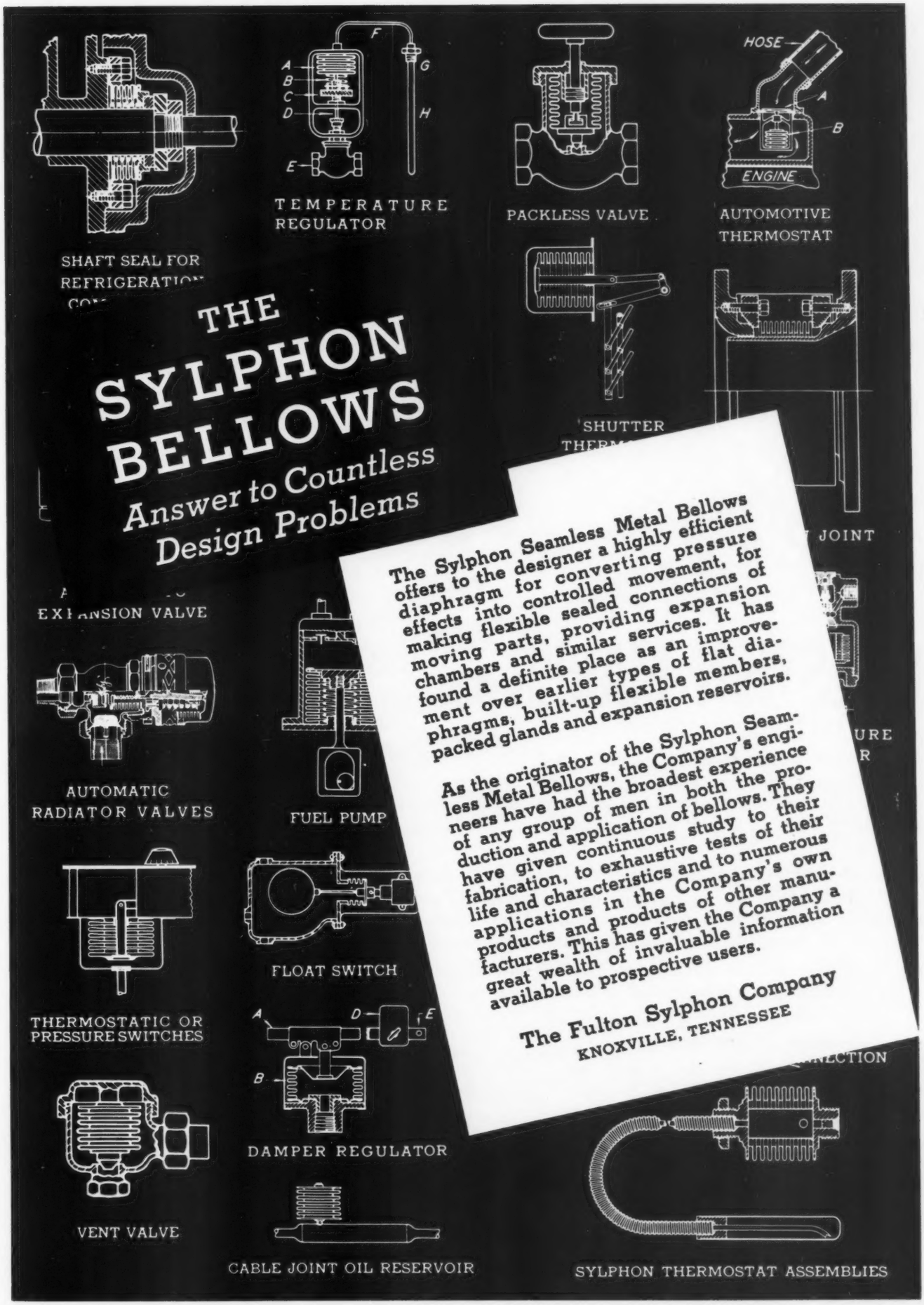
— a wide range of sizes for various applications.

Geared - Vane - Centrifugal

Ask for Catalog.

BROWN & SHARPE MFG. CO.
Providence, R. I., U. S. A.

BROWN & SHARPE PUMPS


SHAFT SEAL FOR REFRIGERATION
TEMPERATURE REGULATOR
PACKLESS VALVE
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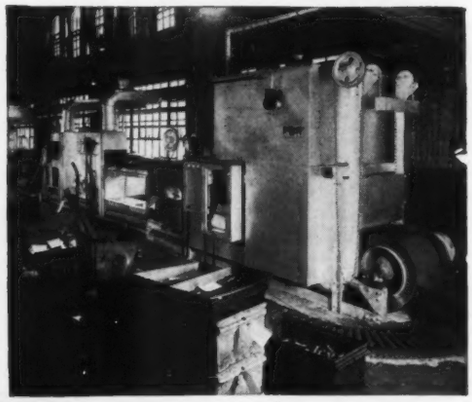
HOSE
ENGINE
SHUTTER
JOINT
EXPANSION VALVE
AUTOMATIC RADIATOR VALVES
FUEL PUMP
FLOAT SWITCH
THERMOSTATIC OR PRESSURE SWITCHES
DAMPER REGULATOR
VENT VALVE
CABLE JOINT OIL RESERVOIR
SYLPHON THERMOSTAT ASSEMBLIES
THE SYLPHON BELLOWS
Answer to Countless Design Problems
The Sylphon Seamless Metal Bellows offers to the designer a highly efficient diaphragm for converting pressure effects into controlled movement, for making flexible sealed connections of moving parts, providing expansion chambers and similar services. It has found a definite place as an improvement over earlier types of flat diaphragms, built-up flexible members, packed glands and expansion reservoirs.
As the originator of the Sylphon Seamless Metal Bellows, the Company's engineers have had the broadest experience of any group of men in both the production and application of bellows. They have given continuous study to their fabrication, to exhaustive tests of their life and characteristics and to numerous applications in the Company's own products and products of other manufacturers. This has given the Company a great wealth of invaluable information available to prospective users.
The Fulton Sylphon Company
KNOXVILLE, TENNESSEE

DOLLAR SIGNS

where there should have been

QUESTION MARKS



Gibson's acknowledged uniformity of heat-treatment is maintained in continuous furnaces automatically controlled.

Scale-testing springs in many sizes insures specified physical characteristics.

Gibson's large stock of ferrous and non-ferrous metals and alloys enables your procurement of small as well as large quantity purchases in a minimum length of time and at advantageous prices.

Before you scrutinize the cost of a good spring, analyze the savings it can bring . . . savings not only in eliminating production losses and replacements, but what is most important, in user *good will.*

A competent springmaker may often save on the cost of your spring, if called in before space limitations have been determined. Many a spring cost has mounted through the necessity of providing a design unnecessarily expensive due to unwise restriction of space.

Gibson engineers share your interest in getting the spring you need at the lowest price, necessary quality considered.

Save dollars . . . get competent engineering help. When you buy springs— call GIBSON.

Gibson SPRINGS

William D. Gibson Co.

DIVISION OF ASSOCIATED SPRING CORPORATION

1800 CLYBOURN AVENUE · CHICAGO, ILLINOIS

Clevelands help keep $1500.00 A DAY IN THE BLACK

"Twenty-four-hour continuous operation in this plant doesn't mean *perhaps*"—writes an Executive in one of the largest firms in his Industry.

"Our machines *must* keep going—because shutting down even one of them would cost us **$1,500.00 a day.**"

"Installations of Cleveland Worm Gearing give us uniform operation and help eliminate shutdowns. Clevelands have won preference here through many years' reliable performance and low maintenance cost."

Thus, still another prominent manufacturer became a large user of Cleveland Units — installing first a few, then increasing numbers as they proved their stamina and endurance.

Install Clevelands with complete confidence on the Machines you build—for Clevelands will stand by you and your customers.

The Cleveland Worm & Gear Company, 3279 E. 80th St., Cleveland, O.

Affiliate: The Farval Corporation, Cleveland, Manufacturers of Centralized Systems of Lubrication
In Canada: PEACOCK BROTHERS LIMITED

CLEVELAND
WORM GEAR *Speed Reducers*

Multiply Man-Power

by Improving

MACHINE PERFORMANCE

TO OFFSET SHORTAGES of skilled man-power, machines must perform at their maximum rated capacities with a minimum of interruptions.

This type of operation demands the ruggedness . . . the trouble-proof qualities . . . of BCA Ball Bearings. Both machine maker and machine user benefit when the designer specifies BCA's.

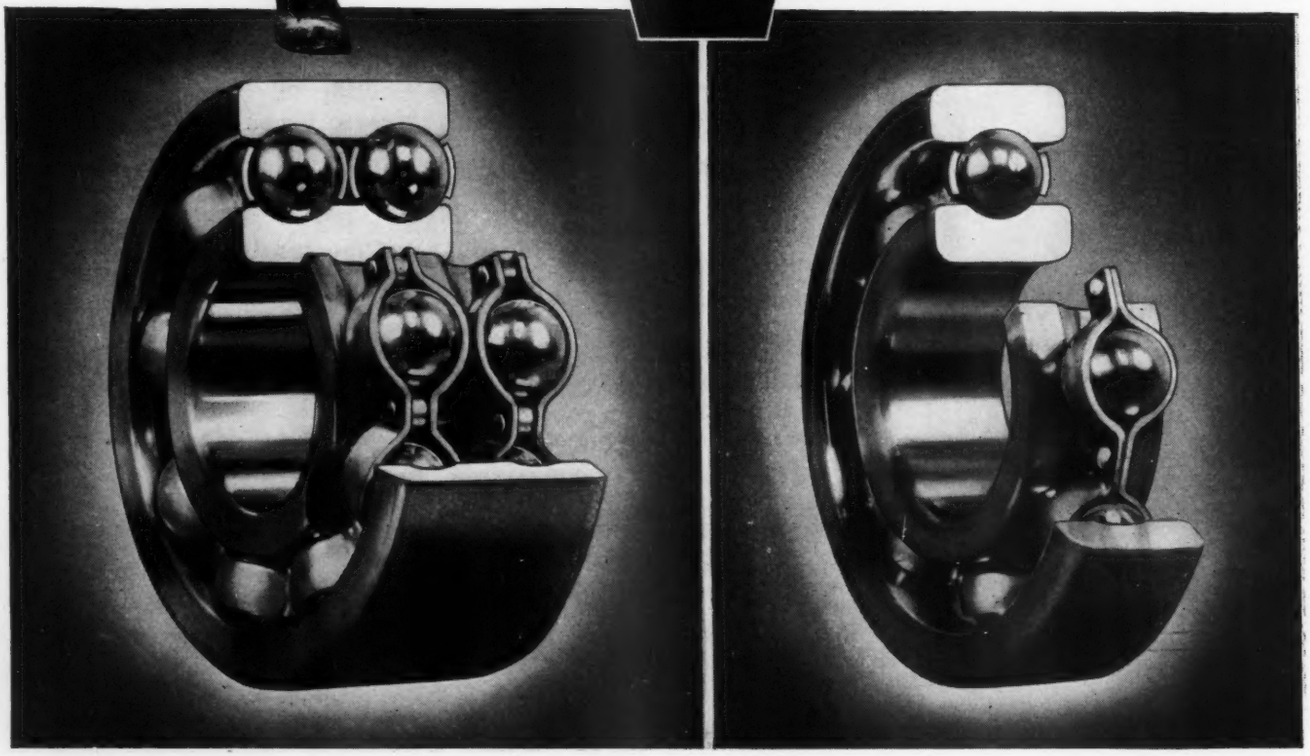
BCA will gladly engineer or help you select ball bearings to meet the exact requirements of your equipment. For full information about loads and life expectancies refer to the BCA Data Book. If you do not yet have your copy of this valuable reference, write us today.

BEARINGS COMPANY OF AMERICA, 412 Harrisburg Ave., Lancaster, Pa.

BCA

RADIAL • ANGULAR CONTACT • THRUST

BALL BEARINGS



Hanna High Pressure HYDRAULIC Cylinders

WHENEVER you are faced with the problem of securing smooth, dependable power movement in any direction, think of Hanna Hydraulic Cylinders. Built in 10 standard models, from 1½" to 8" bore, at working pressures up to 1500 lbs. per sq. in. Write for full details.

HANNA ENGINEERING WORKS
1765 Elston Avenue • Chicago, Illinois

for SMOOTH DEPENDABLE POWER at low cost

the practical side of Springmaking — BY DUNBAR

SPRINGS on the Square

When springs are coiled from square wire the material becomes keystone shape ▼. The keystoning is more pronounced as the diameter of the spring lessens. This effect must be considered when figuring the solid height of springs made from square ■ wire. For figuring this keystoning effect we suggest the following formula:

$$d^1 = .48d\left(\frac{OD}{PD} + 1\right)$$

d = Original wire size. OD = Outside diameter of spring.
d^1 = Width of wire after coiling. PD = Mean diameter of spring.

For best results anticipate the obstacles to good design *before* the springs are made.

Dunbar Bros. Co., Bristol, Connecticut
DIVISION OF ASSOCIATED SPRING CORPORATION
"Quality Springs since 1845"

The **PRODUCTIMETER**
That Records in DECIMALS

Model 5-SMIB-5, illustrated above, built especially by Durant for Flush Mounting on Panels or Control Desks. Ideal for design in machines...can be calibrated to read in decimals of 10ths, 100ths, 1000ths, 10,000ths inches.

Used with selsyn motor sets, for remote readings, or direct drive through gearing from adjustment screws, to indicate setting of rolls, dies, rams or shears.

Quick reading, trouble-free, accurate, dependable.

WRITE FOR COMPLETE DETAILS. SEND YOUR COUNTING ENGINEERING PROBLEMS TO US.

DURANT MANUFACTURING CO.
1938 N. Buffum Street
Milwaukee, Wis.

Twin plants, with complete modern facilities, enable us to fill orders for one spring or millions... meet schedules ...maintain peak quality.

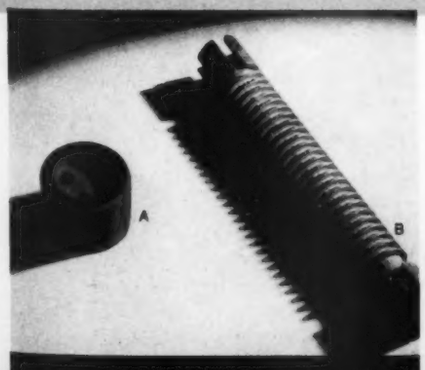
For years we've been licking spring problems of many industries, and that experience is yours for the asking. Laboratory control from raw material to finished product, backed by modern equipment and master craftsmen who *grew up* in spring making.

Yes, you'll get springs on time...and long-life performance that means so much today. *Send inquiries or orders to either plant.*

SPRINGS - WIRE FORMS - SMALL STAMPINGS

BARNES-GIBSON-RAYMOND
DETROIT PLANT — DIVISION OF ASSOCIATED SPRING CORP — COOK PLANT
DETROIT, MICHIGAN ← TWO PLANTS → ANN ARBOR, MICHIGAN

Iron Horses Talk and Hear



A—Connector plug—sawed, turned, and drilled.
B—Coil form—turned, milled, and threaded.

The speed, numbers and tactics of modern tanks make radio communication necessary for effective action. • Communicating systems represent only one of many defense applications for which the Bakelite-laminated industry produces dependable insulation. The industry is working at capacity producing parts of all kinds for the Defense Program and for essential industry. SYNTHANE CORPORATION, OAKS, PENNA.

SYNTHANE TECHNICAL PLASTICS

SHEETS • RODS • TUBES • FABRICATED PARTS

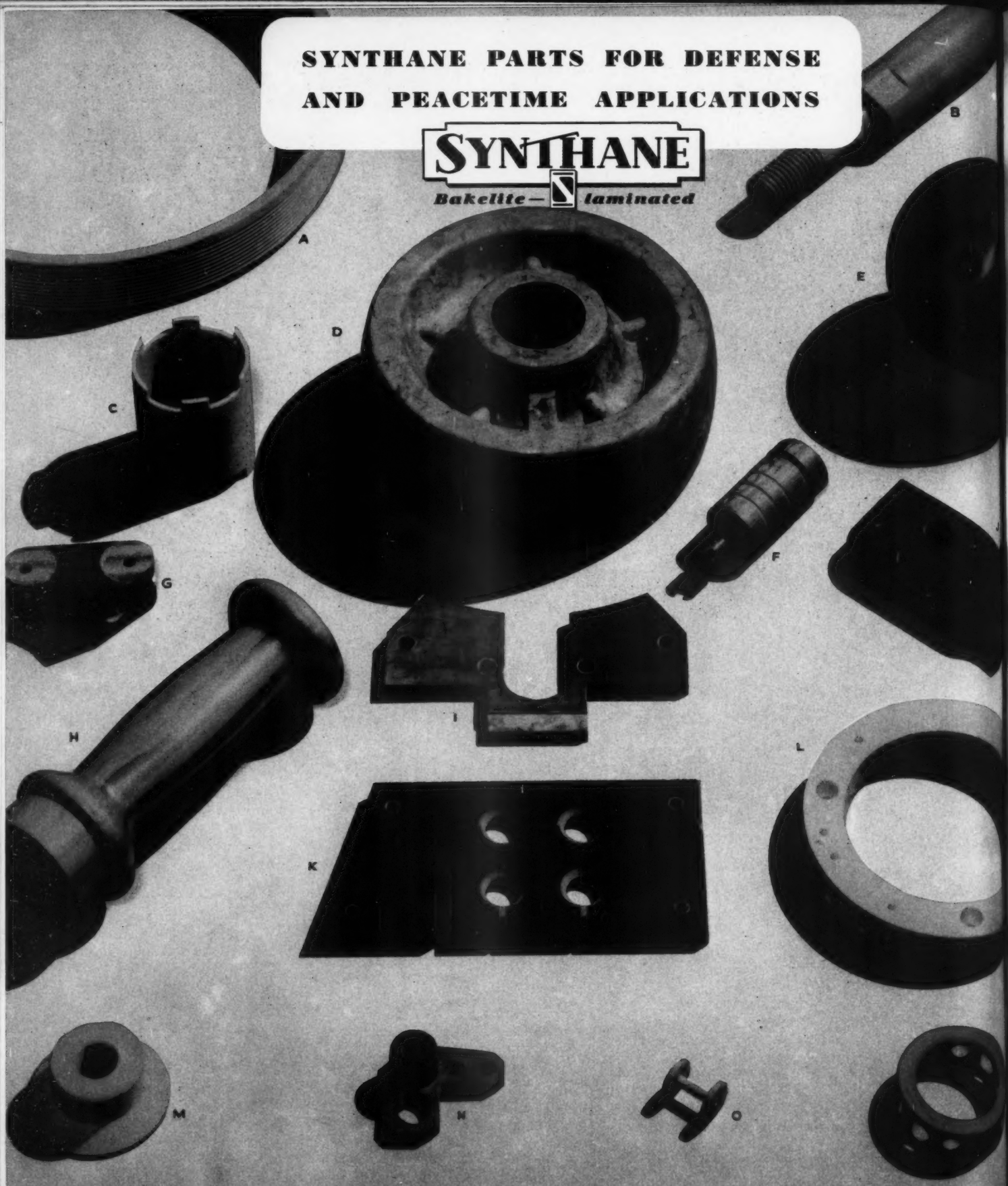
SYNTHANE
Bakelite—laminated

SILENT STABILIZED GEAR MATERIAL

SYNTHANE PARTS FOR DEFENSE AND PEACETIME APPLICATIONS

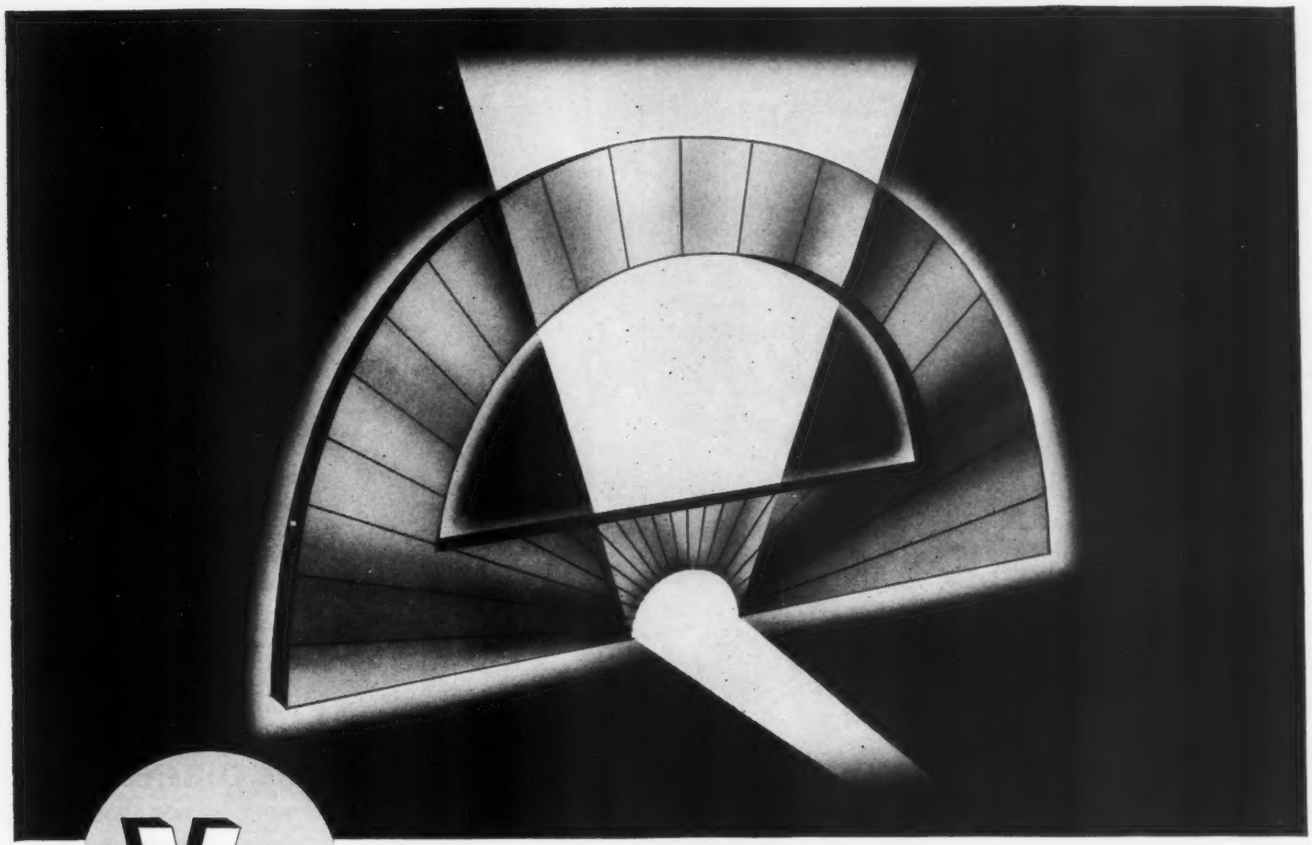
SYNTHANE

Bakelite— laminated



A Airplane radio loop form
B Rod for bottle washing machine
C Variometer stator
D Molded-macerated truck wheel
E Molded-macerated valve check ball
F Airbrake piston
G Aircraft part
H Handle for hosiery ironing device
I Aircraft propeller part
J Aircraft part
K Airplane fairlead
L Brush holder bracket
M Plug end, rayon industry
N Aircraft part
O Radio coil spool
P Ball bearing retainer

SYNTHANE CORPORATION, OAKS, PA.



THE DOMINANT DRIVE OF INDUSTRY

TRADE MARK

The use of this emblem by an association member in connection with Multiple V-Belt Drives is your assurance of mechanical excellence—the result of cooperative engineering, research and experience.

light on the "right" angle

The tremendous importance of apparently trifling details has been demonstrated by engineering practice times without number. And, in the matter of correct angles of the Sheaves and V-Belts used in Multiple-V-Belt Drives, this truth is most forcibly emphasized. . . . Countless laboratory experiments and field tests by Association Members were necessary to determine the precisely "right" angle to provide maximum wedging-gripping action with the least allowable tension to insure highest efficiency, plus long, uninterrupted service life of both sheaves and belts. . . . Today, the smooth, quiet functioning of thousands of Multiple-V-Belt Drives in practically every industry is accepted as a matter of fact. The arrival of the "right" angle is another example of coordinated effort by Association Members that made the Multiple-V-Belt Drive "The Dominant Drive of Industry".

MULTIPLE-V-BELT DRIVE ASSOCIATION
140 SOUTH DEARBORN STREET • CHICAGO

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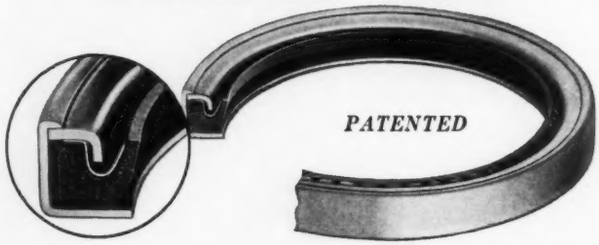
MAINTENANCE COSTS ARE DOWN

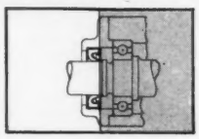
WE INSTALLED

GARLOCK KLOZURE OIL SEALS

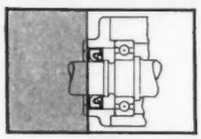
TO PROTECT OUR BEARINGS



THEY KEEP OIL AND GREASE IN



THEY KEEP DUST, DIRT AND WATER OUT



Production goes up and maintenance costs go down when your bearings are protected with Garlock KLOZURE oil seals. Insure against shut-downs due to bearing failures by installing these sturdy, effective and economical seals. Complete range of sizes including KLOZURES made to bearing manufacturers' standard metric bore sizes.

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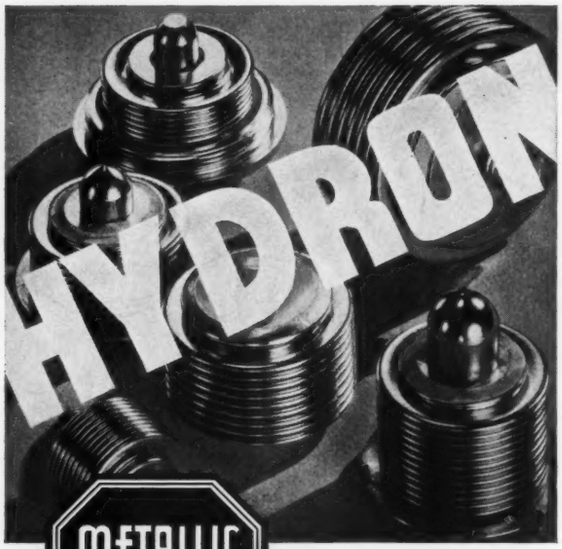

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PRODUCERS OF BELLOWS EXCLUSIVELY
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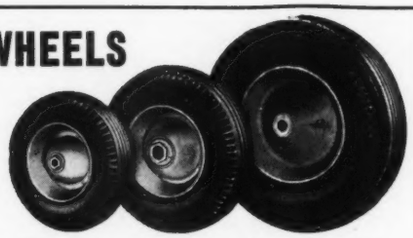
DOENUT WHEELS

REDUCE COSTS

SAVE TIME



New Doenut Wheels with outside valve will do a better and faster handling job in your plant—and at a lower net cost per year. They increase the work per man hour; preserve floors and stop noise.

Valves cannot be cut or damaged from "creeping" because of under-inflation. Available in three sizes: 10" x 2.75"; 12" x 3.30"; 16" x 4.40". Kindly state axle size, maximum load per wheel and nature of application for proper recommendations.

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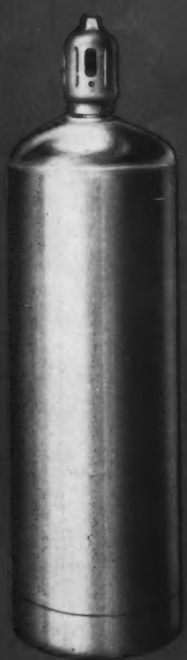

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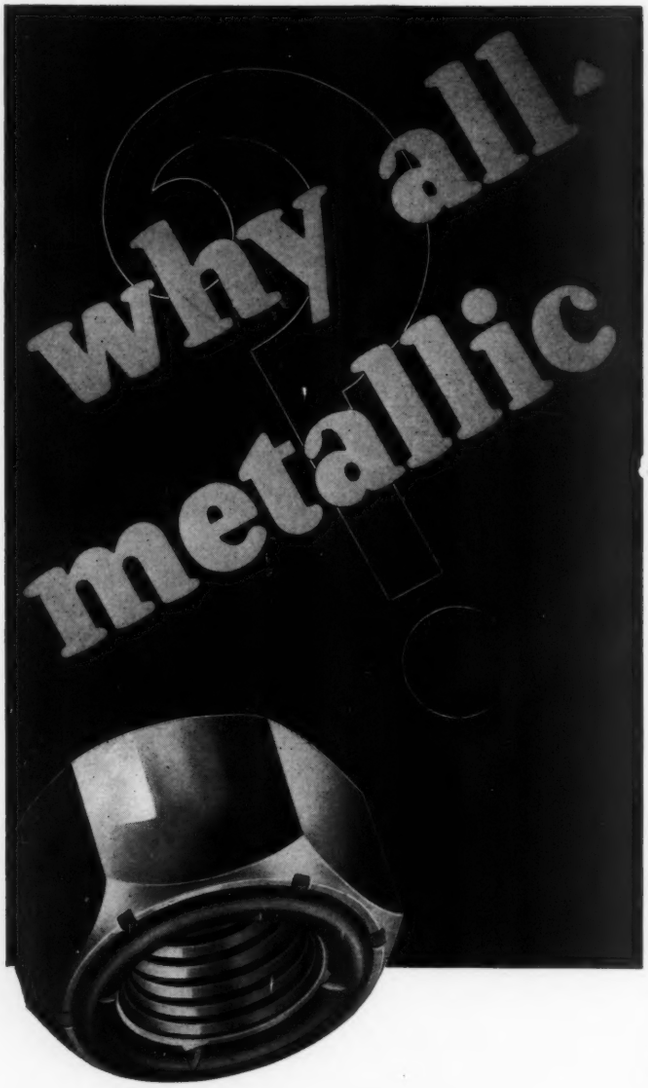

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• In high-temperature applications, for example, the all-metal An-cor-lox lock nut (patented) is unaffected by normal operating temperature. *For extreme temperature or corrosive condition you specify the best material for the job.* • A lock nut you can depend on for real locking security and safety! As easily applied as an ordinary nut—requires only standard wrenches, bolts, threads, and application methods. Can be re-used repeatedly! Send for sample.

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Heart of the FRIEND sprayer is the simple, sturdy pump. Its few working parts, selected for their strength and long life are the secret of its satisfying, low-cost operation. FRIEND Co. engineers place as much importance on the strength and ruggedness of the drive as on the pump itself. So they use Ohio Gears. "There can be no compromise with quality," they say, "on any of the parts going into this product. Close tolerances and accuracy of workmanship are absolutely essential for gears of the sort we use and we have found the Ohio Gear Company a most reliable source of supply."

Transmissions for spray equipment is another of the many interesting ways Ohio Gear products are serving industry by providing reliable, low-cost power transmission.

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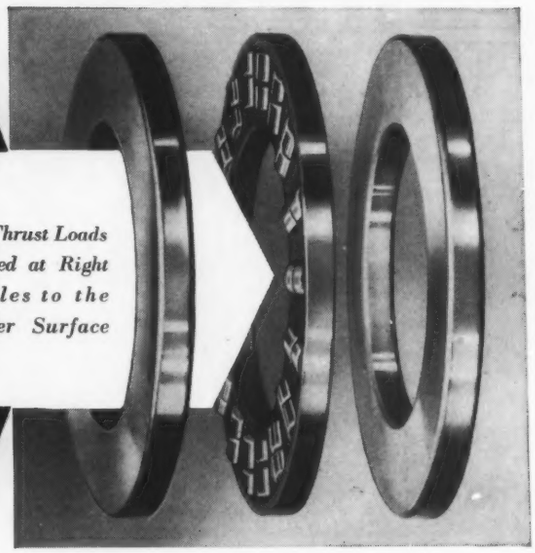
LONGER BEARING LIFE

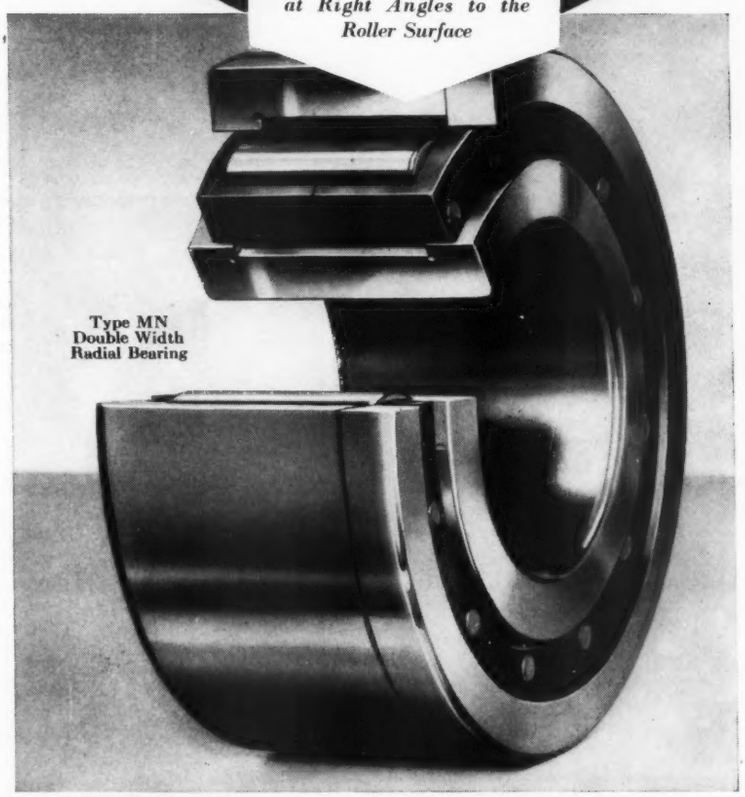
Under Heavier Loads At Higher Speeds—

Type T
Single Acting Thrust Bearing



All Thrust Loads carried at Right Angles to the Roller Surface

All Radial Loads Carried at Right Angles to the Roller Surface



Type MN
Double Width
Radial Bearing

REMEMBER—with Rollways, "change over" to bearings of higher load ratings usually does not require redesign of the size relation of other parts of the machine.

ROLLWAY'S
RIGHT-ANGLED LOADING
gives better all-around service under the 168-hour week

Where design requires simplified assembly to secure the greatest bearing area and capacity, Rollway double-width Radial bearings—with separable outer race—will carry heavier loads with reduced wear, even under extreme conditions.

Like all Rollway Bearings—both Radial and Thrust types—this double-width series has solid cylindrical rollers, especially designed for the compactness and extra load capacity *achieved through right-angled loading.* In addition, due to its construction, it will take a relatively heavy locational thrust. It is interchangeable in boundary dimensions required for standard double-row ball bearings of S.A.E. sizes. And the two-part feature of the outer race simplifies the mounting problem—an important consideration in many applications.

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Send us your plans today for engineering analysis and bearing recommendations.

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BUILDING HEAVY-DUTY BEARINGS SINCE 1908 **BEARINGS**

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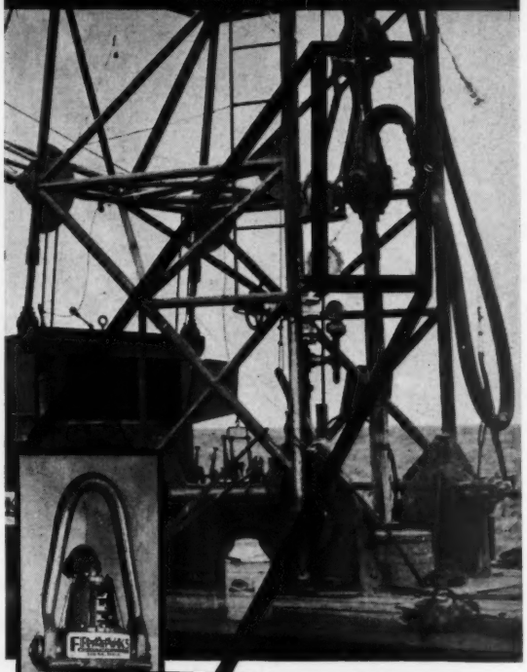
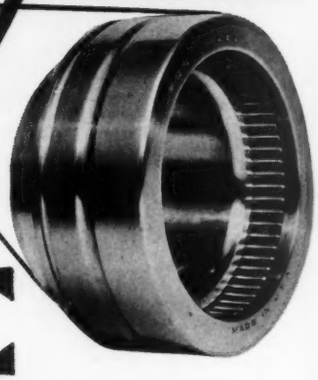
FRANKS MFG. CORP. WELL SERVICING AND DRILLING UNITS

MODEL 5200 SWIVEL

Eliminates Wobble



On this OIL RIG, STEM Alignment Insured by LOWER RADIAL BEARING — an



RBC CYCLOPS NEEDLE BEARING

Designed and built to carry heavy radial and shock loads, the RBC CYCLOPS performs at high efficiency in the operation of this Franks Swivel. It keeps the stem in alignment and helps eliminate the wobble of the drill pipe. The bearing used on this job has an inner race with an inside diameter of 4½". Other CYCLOPS Bearings are available for use on shafts from ½" to 8" in diameter.

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ALTER EGO: Literally, "one's other self"—the still, small voice that questions, inspires, and corrects our conscious action.

But I'm too busy to change over to welded design.

ALTER EGO: Why not change over gradually —*one part at a time?* That way you could prepare for the future and get faster production today with welding.

What do you mean, prepare for the future?

ALTER EGO: Get well set for the Battle for Business. Economize!

But I did economize by changing over that sprocket housing some time ago.

ALTER EGO: Right! And you saved $8.70 on every one. Keep it up! Don't forget to *change* your designs to welded steel and get your change in cash!

• •

LINCOLN SUGGESTS: Profit from the experience of others—see *what* they have done and *how* they did it with arc welding. This will help you change over to welded construction with a minimum of lost motion. Machine Design Sheets, issued regularly, show various approaches to the design of parts—compare costs and weights of each. These will guide you. Ask for Application Sheet No. 75.

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LINCOLN "SHIELD-ARC" WELDING THE LINCOLN ELECTRIC COMPANY Cleveland, Ohio

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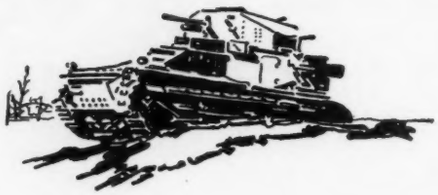
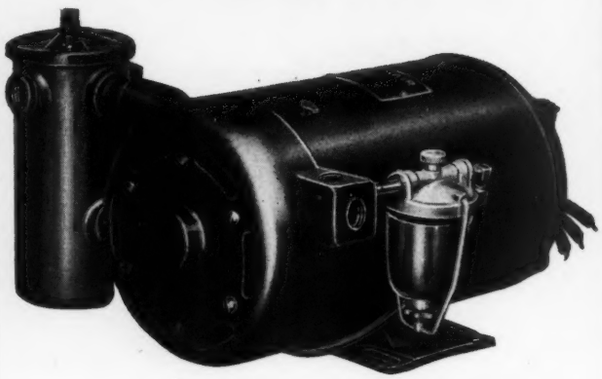


DEFENSE INDUSTRIES
find plenty of need for

MOTOAIR



the PUMP for vacuum or pressure

- **NO GEARS**
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- **NO DRIVES**

Motoair can be mounted in ANY position, as an accessory to machines utilizing vacuum or pressure. Note its compact design; put it to test on *your* units because it does a better job.

- No pulsation—less parts to wear out—a visible lubrication system.

An ideal, portable unit for cleaner-blower work, from plug-in line, for factory, shop, woodworking or laboratory use. Widely used for lens cleaning by vacuum, and in many paper-handling machines.

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WIRE FORMS
Try them out!
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DIVISION OF ASSOCIATED SPRING CORPORATION
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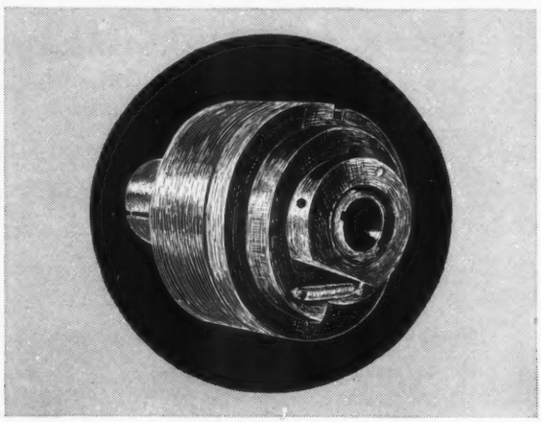

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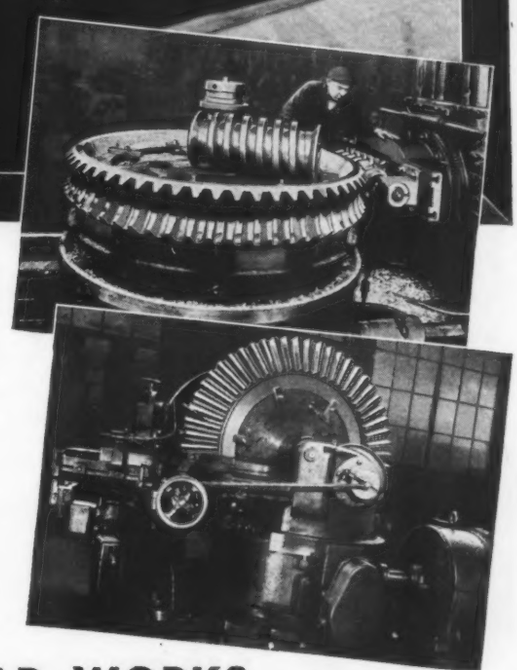

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Modern design of oil and gas space heaters calls for the controls to be conveniently placed on the front panel. As a result, the control handles or dials are generally at some distance from the fuel valves. A means must, therefore, be provided for carrying the control from the handles or dials to the valves.

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A TYPICAL EXAMPLE

In this attractive, modern QUAKER Oil Heater—product of the Quaker Manufacturing Co., of Chicago—an S. S. WHITE Remote Control Flexible Shaft, extending from the calibrated control dial at the upper right to the oil valve in the base, provides sensitive heat regulation.

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Always available for working out specific applications . . . . Send Us Details.

DATA FOR ENGINEERS

Bulletin 38 gives details about S. S. WHITE Remote Control Flexible Shafts and their application. A copy will be mailed at your request.

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The S. S. White Dental Mfg. Co.
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FLEXIBLE SHAFTS for POWER DRIVES, REMOTE CONTROL and COUPLING

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Speed Ranges up to 16 to 1
Sizes — 1 to 30 hp.

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YOUR COOLANT PROBLEM AND
WE'LL SHOW YOU..
A PUMP TO SOLVE IT!

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There's a Gusher Coolant Pump for virtually any machine tool made. There are motor driven models; belt driven models; plain drive models. Installation outside the reservoir, or for immersion in the reservoir. Small or large capacity models to suit the job.

A Gusher model to speed your work. Write!

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P3 models are available in immersed type (1-P3), flange-mounted with internal discharge (2-P3), flange-mounted with external right hand discharge (3-P3), left hand discharge (4-P3). All above are available in short and long models, that is, for two maximum high water lines.

Pat. and Pats. Pending.

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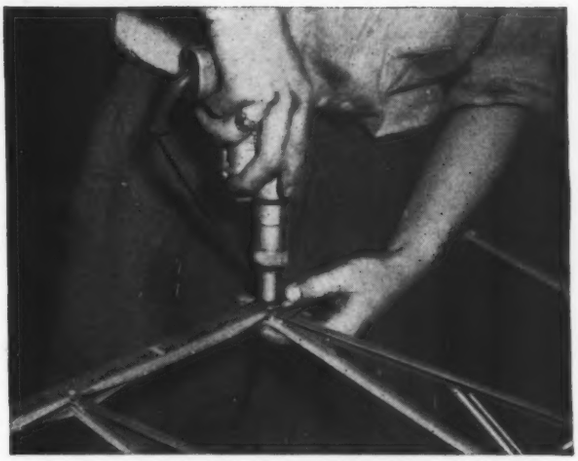
LARGEST EXCLUSIVE BUILDERS OF COOLANT PUMPS

Can YOU stretch a work-week to 8 days?

It HAS been done on many assembly jobs . . . A P-K Assembly Engineer may point the way for you!



TAYLORCRAFT SPEEDS ASSEMBLY *of planes for Civilian Pilot Training Program by using Parker-Kalon Self-tapping Screws for many applications. The assembly shown above is typical.*

Whether you make planes, tanks, bombers, or any of the thousands of other products for defense, or for essential civilian needs, in today's vital task of getting more assemblies per man-hour, a Parker-Kalon Assembly Engineer can be a big help! He can help you effect time-savings of 25 percent to 50 percent in the many assemblies suited to Parker-Kalon Quality-Controlled Self-Tapping Screws. Wherever the P-K Engineer uncovers a place to use this simpler method . . .

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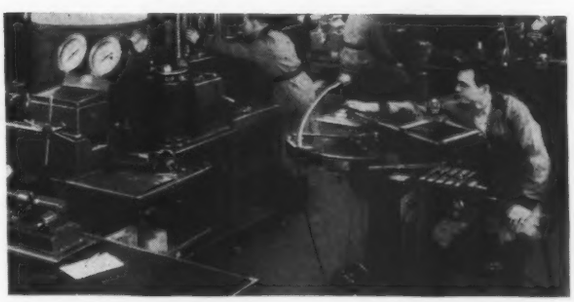
You gain secure fastenings . . . actually stronger than fastenings made with machine screws in tapped holes, or with bolts and nuts and lock washers!

You cut out "slow-ups"! Every genuine Parker-Kalon Screw drives easily and holds tight. The unequalled Parker-Kalon Quality-Control Laboratory routine protects against "doubtful screws" . . . screws that look all right but some of which fail to work right.

CALL for a Parker-Kalon Assembly Engineer to go over your fastening problems. You'll quickly see why some of industry's largest plants regularly use this advisory service. Or send assembly details for recommendations and samples. Parker-Kalon Corporation, 196 Varick Street, New York.



The Screw Industry's Finest Quality-Control Facilities

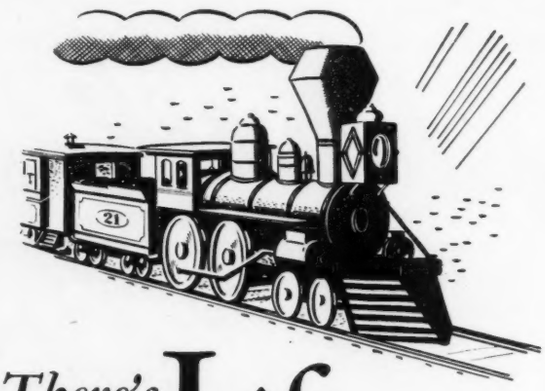
PARKER-KALON

Quality-Controlled

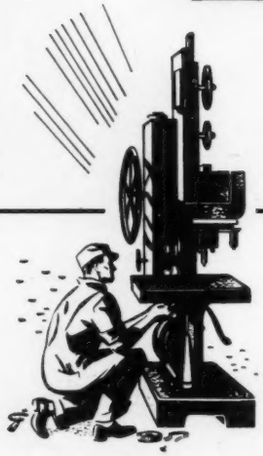
SELF-TAPPING SCREWS

Give the Green Light • to Defense Assemblies

SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY . . . AND OTHER FASTENING DEVICES



There's Life *in the Old Timers!*



SPRINGS for the repair of old machines . . . . .

handled RUSH *at* MUEHLHAUSEN

★ Many of our customers have discovered that there is a lot of production life left in some of the old machines that have been shoved back in the corner as "obsolete." Possibly a little tightening up here and there, and a new spring or so would put some of your "old timers" back in production. (An eastern organization recently took an old planer out of a *museum* and put it back to work!)

To help you with such work, Muehlhausen has a special small order department. Just mark your order "Rush — Repair." Send us the old sample (or broken pieces) or rough sketch of the item needed, and we will do the rest. Any size material from .004" to 2" round; any type of spring — compression, extension, torsion or flat.

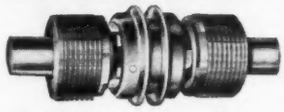
MUEHLHAUSEN SPRING CORPORATION,
808 MICHIGAN AVE., LOGANSPORT, INDIANA.

MUEHLHAUSEN SPRINGS

EVERY TYPE AND SIZE

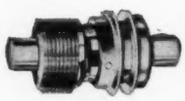
Pullmore Clutches

Selected for Hoist-Control In Yardmaster Straddle Trucks



Double-Type Pullmore

PULLMORE Multiple-Disc Clutches are made in single and double types; for operation in oil or dry; in capacities ranging from 1 h.p. to 75 h.p. at 500 r.p.m. Investigate the many advantages of Pullmore Clutches. Ask also about Rockford Plate Clutches.



Single-Type Pullmore

". . . recommended by satisfied users"; Pullmore Multiple-Disc Clutches were selected for hoisting gear control in Willamette Hyster Company's Yardmaster Straddle Trucks. Pullmore Clutches are particularly suited to the high speeds, frequent operation, and heavy loads of this service. Pullmore Clutches are highly successful in a wide variety of automatic, and semi-automatic machines. Write for the Pullmore Blue Book containing details and data.

Pullmore Clutches are sold by Morse Chain Co. offices in principal cities.

Rockford Drilling Machine Division *Borg-Warner Corporation*
▼ 209 Catherine Street, Rockford, Illinois, U.S.A. ▼

UNCANNY

but it works!

Cutout Section Showing Locking Ring in Place

UNSHAKO

Reg. U. S. Pat. Off.

SELF-LOCKING NUT

Almost mysterious in its ability to *hold tight,* the famous "Unshako" is a simple, fool-proof device you can depend on to G-R-I-P wherever vibration is the problem.

Saves maintenance time, reduces breakdown trouble!

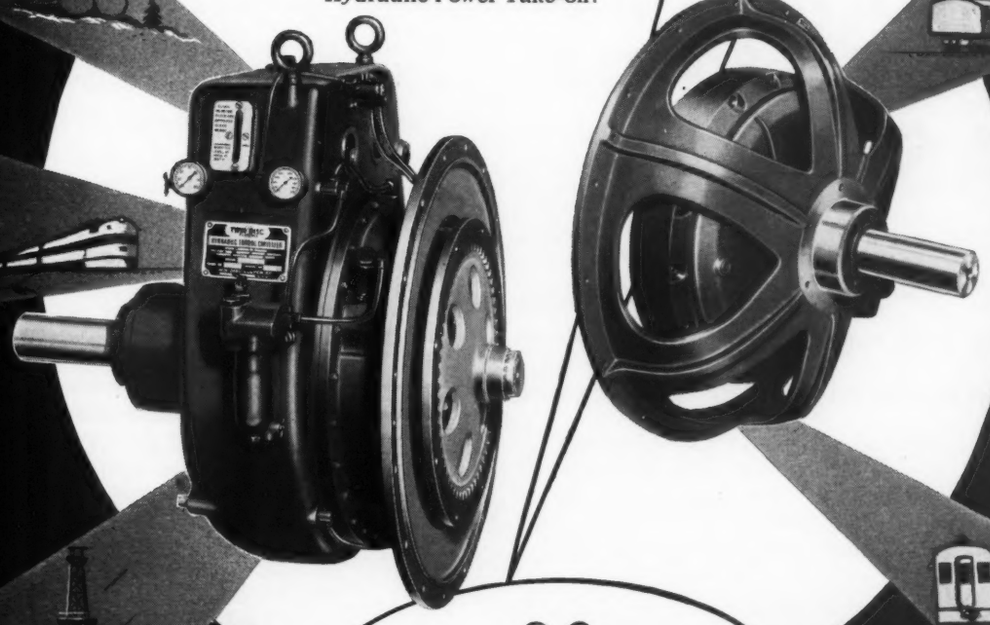
Details free on request, write—

STANDARD PRESSED STEEL CO.
JENKINTOWN, PENNA. 90x545
BRANCHES
BOSTON • DETROIT • INDIANAPOLIS • CHICAGO • ST. LOUIS • SAN FRANCISCO

They all point to HYDRAULIC DRIVES

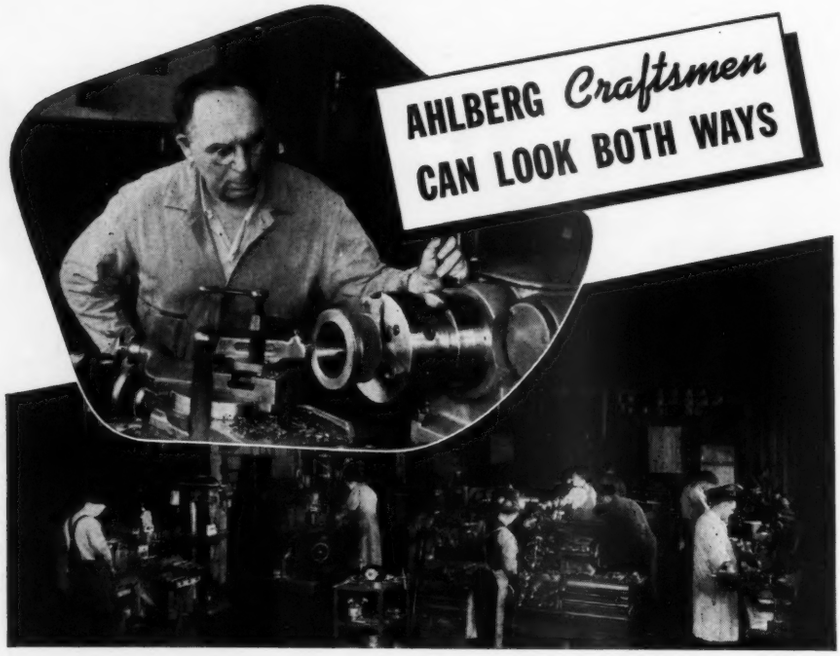
Any job on which the use of high speed internal combustion engines demands the repeated starting of heavy loads . . . or an excessive amount of gear shifting to accommodate varying load conditions is a typical job for the Twin Disc Hydraulic Drive. Case studies on hundreds of working examples, in a wide variety of applications, are now available to any engineer who is planning to take advantage of the definite trend to hydraulic drives—either a Hydraulic Torque Converter or a Hydraulic Clutch. Ask for Bulletin 132 or write the Hydraulic Department for definite recommendations.

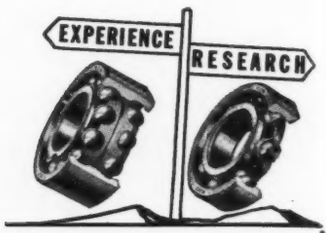
ILLUSTRATED: *Left, Hydraulic Torque Converter and right, Hydraulic Power Take-off.*



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U. S. PAT. OFF.

TWIN DISC CLUTCH COMPANY, 1339 RACINE STREET, RACINE, WISCONSIN





Nowhere does experience count more than in the tool room where the dies, form tools and other precision tools are developed for use in the production department. Ahlberg craftsmen must be able to look back to experience which has shown what can't be done. And they must also be alert to look ahead, eager to find the new way to do a job better.

That is why Ahlberg's tool makers constantly look both ways. They have a rich accumulation of a third of a century's experience in the problems of precision bearing manufacture. But their tools and equipment and their methods are as up to the minute as your evening paper. From drafting board to Magnaflux test there isn't an old machine in the plant.

AHLBERG BEARING COMPANY

Manufacturers of (CJB) Master Ball Bearings

3019 WEST 47TH ST. CHICAGO, ILL.

CJB Ahlberg BALL BEARINGS

Call in HAYS IF IT'S CAST OF BRASS

The decks are cleared for action at Hays—a large modern brass foundry and machine shops working day and night have hit a stride that can step in and do a job for some cast brass product that is vital to your defense contract. Count on Hays to help you in meeting emergency deliveries in cast brass finished to your specifications.

Hays representatives will call at your request.

HAYS MFG. COMPANY, ERIE, PA.

MORE READERS THAN EVER!

TODAY, more than ever, designers are seeking information — both advertising and editorial—on the tools of their trade: materials, mechanical parts, finishes, fabrication methods. This issue of PRODUCT ENGINEERING is being mailed to 12,000 paid subscribers—and will be read by more than 30,000 designers like yourself.

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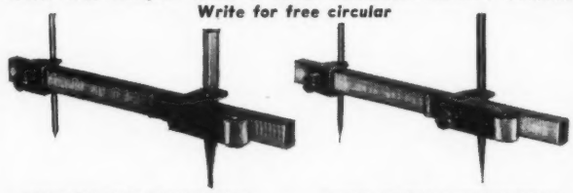
WITH THE UNIQUE RACK & GEAR CONTROL PATENT 2106398

Write for free circular



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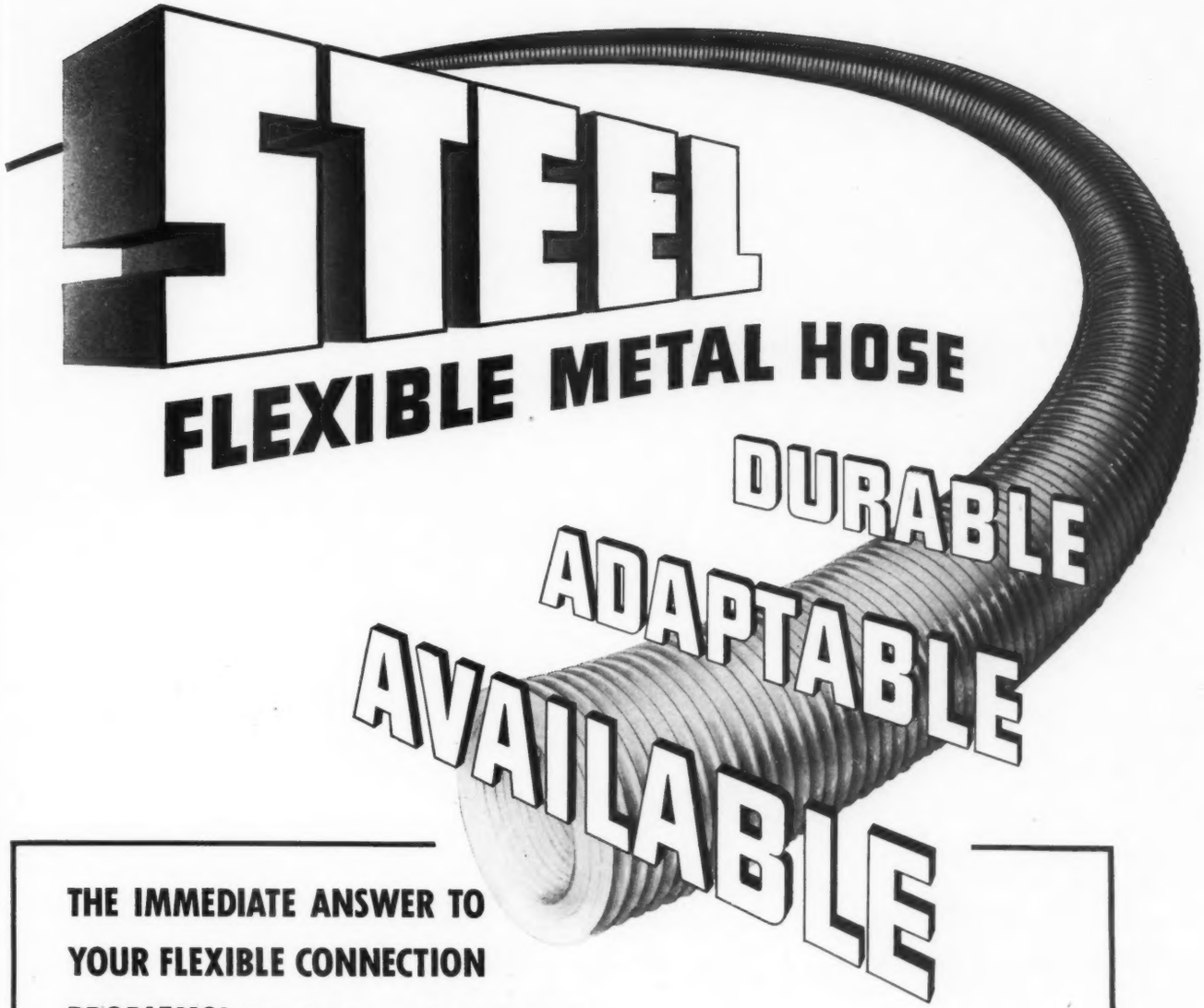
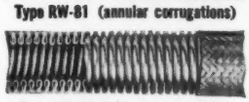
STEEL
FLEXIBLE METAL HOSE



THE IMMEDIATE ANSWER TO YOUR FLEXIBLE CONNECTION PROBLEMS! ***Ask for Complete Data on***

REX-WELD **(corrugated) Flexible STEEL Hose**

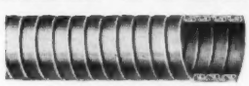
Type RW-81 (annular corrugations)



Type RW-91 (helical corrugations)

Sizes from ⅛" I.D. Pressures to 14,500 p.s.i. Temperatures to 1000° F. One-piece, all-steel construction. Continuous lengths to 50 feet.

REX-TUBE **(interlocked) Flexible STEEL Hose**



Type RT-15 (interlocked)

Sizes from ½" I.D. Asbestos packed.

★ **STEEL COUPLINGS** *available for Rex-Weld and Rex-Tube Flexible STEEL Hose*

CHICAGO METAL HOSE CORPORATION

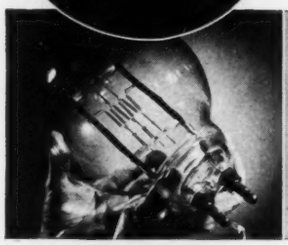
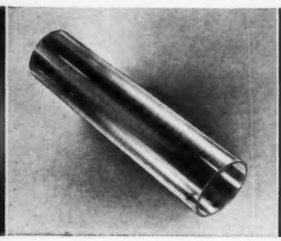
MAYWOOD, ILLINOIS

Chicago Phone: Mansfield 3666

Pyrex Brand Industrial Glass Parts Are

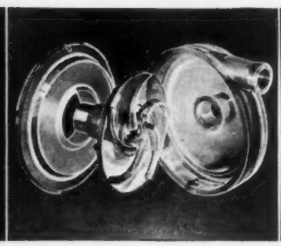
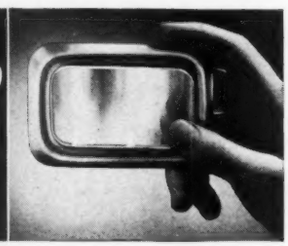
Applicable

Wherever the combined advantages of chemical stability, heat resistance, crystal clear transparency, hardness, mechanical strength and ease of cleaning are important, the use of PYREX brand Industrial Glass Parts may be the solution to your problem.

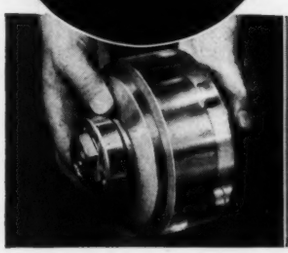
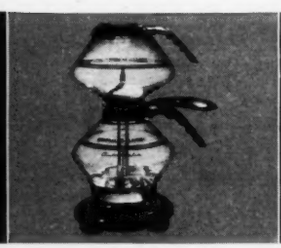
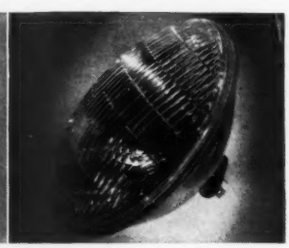
Practical

Because product engineers have found it practical, they have specified PYREX brand Industrial Glass for parts in such widely varied products as springs and pumps. The possible uses of this resistant glass are increased because it can be directly joined to metal in several different ways.

Accurate

Don't pass up the many advantages of PYREX brand Industrial Glass because of accuracy requirements. Corning's ability to produce glass parts to close dimensional tolerances has cured the headaches of many designers and engineers.

Corning Engineers gladly offer the benefit of their years of experience with glass to assist you in the application of glass to the design of a new product or improvement of a present product. Write to them.

"PYREX" is a registered trade-mark and indicates manufacture by Corning Glass Works.

CORNING
Glass Works
Corning, New York

Pyrex Industrial Glass

PYREX NEWS

1. *500 Watt Lamp*

This lamp called not only for an air-tight glass-to-metal joint, but also for the transparency, accuracy and thermal shock resistance of PYREX brand Electrical Glass.

2. *Blue Print Machine Roller*

A PYREX Cylinder provided the transparency, mechanical strength and heat resistance to produce an improved blue print machine design.

3. *Humidifier Float*

One of the simplest methods of attaching glass-to-metal is demonstrated in this Humidifier Float (specially designed for the MorencyVanBuren division of Scoville Mfg. Co.). The ears on the metal spud are clamped firmly to the glass float. This type of joint will last indefinitely where high tensile strength is not of major importance.

4. *Glass Spring*

The ability to produce PYREX brand Industrial Glass to definite specifications involving shape and resiliency was responsible for producing a chemically resistant glass spring having outstanding resistance to fatigue.

5. *Glass Pump*

The chemical stability, accuracy, mechanical strength and resistance to thermal shock of PYREX brand Industrial Glass, plus a glass-to-metal joint, made possible a glass pump that solved many corrosion problems in the chemical field.

6. *Meter Index Window*

A metalized edge fused to the glass made possible a soldered air-tight seal required for a gas meter index window.

7. *High Pressure Glass Roller*

A high pressure glass roller securely mounted on ball bearing drive shaft. The roller surfaces are ground and polished to close tolerances for both flatness and concentricity. This is another example of mechanical strength and precision obtainable in glass-metal assemblies.

8. *Glass Coffee Maker*

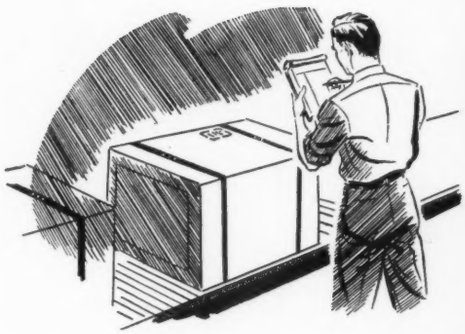
PYREX brand Industrial Glass was chosen for an automatic coffee maker because in addition to other desirable qualities, PYREX glass blanks can be fabricated to precise dimensional tolerances.

9. *Sealed Beam Headlight*

Accuracy of machine pressed PYREX glassware produced the precise contour of the paraboloid surface necessary to the satisfactory performance of the sealed beam headlight.

Do Your Machines Answer: "HERE!"

when the Production-Roll is Called?



Make sure that the production machines you design and build are *power-fit* to maintain their full rated capacity of output under today's non-stop operating conditions. Build the extra strength of Whitney Chains into every drive . . . and get *total transmission* of power to the job, at constant speeds that keep product-quality uniform. These tough alloy-steel roller and silent chains assure top levels of drive-performance at lowest levels of cost, over the longest span of service. So get the *power priority* of Whitney Chains to make your machines 100% fit for defense production.

The Whitney Chain & Mfg. Co.

Hartford, Connecticut

WHITNEY PRODUCTS Roller Chain & Sprockets, Silent Chain & Sprockets, Conveyor Chain & Sprockets, Roller Chain Flexible Couplings, Automatic Load Limiting Sprockets, Automatic Drive Tensioners, Woodruff Type Machine Keys and Cutters.

WHITNEY

ROLLER AND SILENT CHAINS FOR POSITIVE POWER TRANSMISSION

. . . for Army and Navy Parts

MADISON-KIPP hi-high PRESSURE ALUMINUM DIE CASTINGS

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● We are handling orders for millions of die castings, difficult castings and vital parts for nearly all branches of U. S. defense and U. S. aid efforts. (Many of these parts were originated as die castings at Madison-Kipp). ● We will be pleased if we can be of assistance to you when you bid on Government contracts and also in furnishing die cast parts or assemblies after you have closed your deal. ● We can usually give price and delivery information by telephone because of having had over two years experience in developing special equipment and producing castings for Boosters, Fuzes, Bombs, Shot and other Ordnance parts. ● Just telephone Badger 7051, Madison, Wisconsin, and ask for the Ordnance Sales Department.

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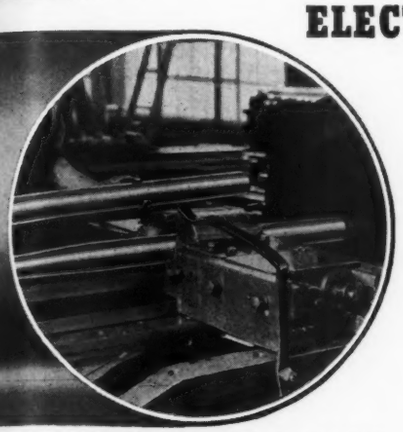
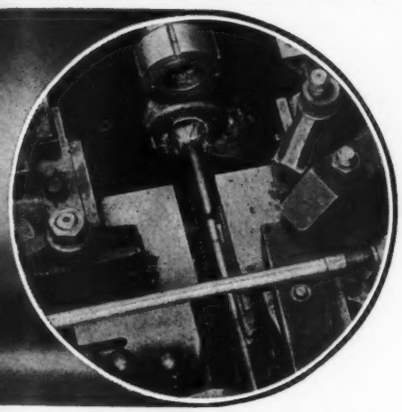
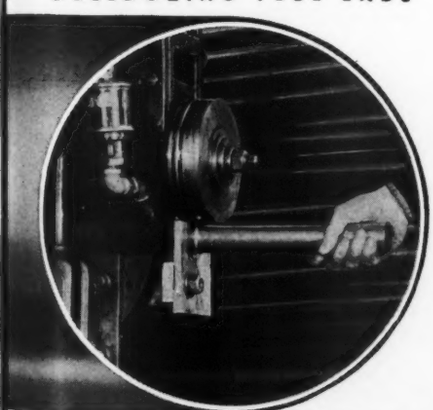
ELECTRIC RESISTANCE WELDED TUBING



SWAGING PROPELLER SHAFTS



BULLDOZING TUBE ENDS



ROLLER BEADING TUBES

You can fabricate Republic ELECTRUNITE Tubing by any modern method to practically any required shape. And you can do it on a high-speed production basis with full assurance of quality maintenance—because ELECTRUNITE is uniformly and readily *workable.*

Unlike tubing made by other processes, Republic ELECTRUNITE is cold-formed and electric resistance welded. It retains all of the original ductility and strength of the steel throughout the entire tube structure. Hence it may be cold-worked *easily* and *accurately.*

Because of its method of manufacture, Republic ELECTRUNITE Tubing obtains a consistent uniformity of diameter, wall thickness and concentricity that further insures unvarying workability and a steady output of sound, perfectly-formed tubular parts.

You can bend, flange, expand, swage, upset, bead, groove, roll, knurl, spin, flute, flatten, coil, taper and thread Republic ELECTRUNITE Tubing without difficulty.

If your product involves the use and fabrication of tubing, you may be pleasantly and profitably surprised by the increase in workability you can obtain by changing to Republic ELECTRUNITE Tubing. It is made in carbon steel and *Enduro Stainless Steel in standard sizes and gauges. Tell us what you make and how you fabricate it. Our engineers will be glad to tell you in detail what ELECTRUNITE can do for you. Steel and Tubes Division, Republic Steel Corporation, Cleveland, Ohio.

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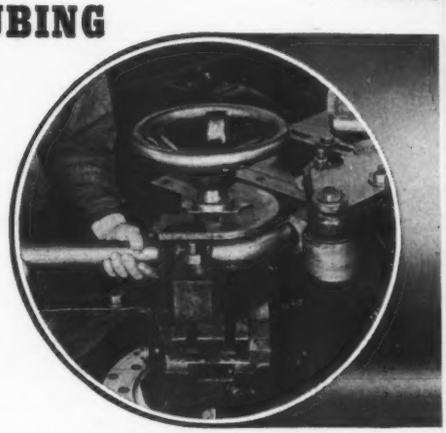
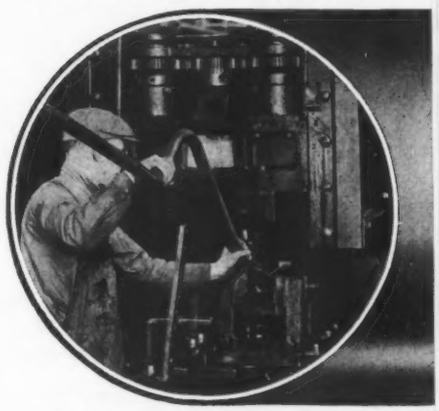
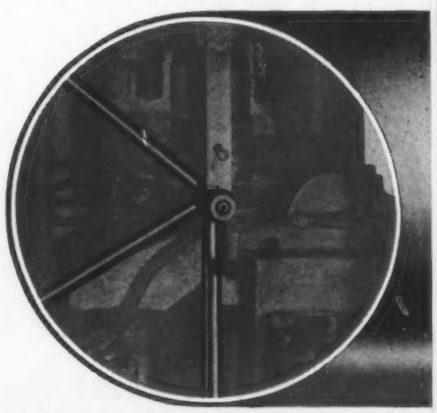


PEDESTAL TYPE BENDING



PRESS TYPE BENDING



HART PROCESS WELDING

Republic ELECTRUNITE

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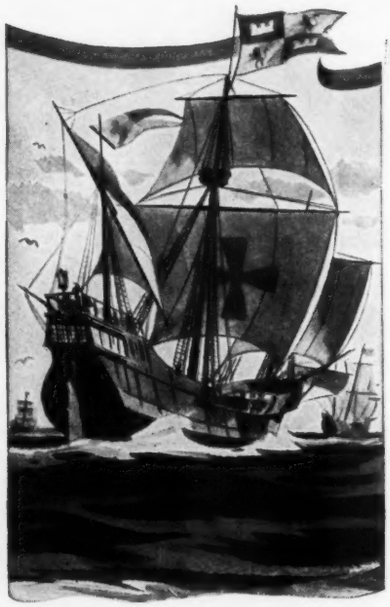
ELECTRIC RESISTANCE WELDED TUBING

Also Boiler Tubes . . . Condenser and Heat Exchanger Tubes

In search for the Indies ... they found America!



Today many companies forced by priorities to give up metals formerly used in their products, have switched to Porcelain Enamel. They were searching for a "substitute"—but they found in Porcelain a *better* material!

It's giving them advantages and selling points they never had with their old materials—for Porcelain Enamel is one of the most durable and versatile finishes known to man. It is *glass fused to metal* at extremely high temperatures. It has a permanence and luster that withstand all temperature and corrosive conditions.

Recently, to meet a deluge of inquiries we created a special division of our laboratories to act in an advisory capacity for manufacturers faced with priority problems.

If your production is threatened by priorities in Aluminum, Nickel, Stainless Steel, Zinc, Chromium, Copper or Cadmium, send us your blueprint or specifications today! Our staff of skilled engineers will analyze your problem and make unbiased recommendations without obligation. Write now to: Department P-2.

THE FERRO ENAMEL CORPORATION
Cleveland, Ohio

FERRO

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WHAT FELT
would you specify here?
LOOK BELOW FOR YOUR ANSWER
The BOOTH mechanical felt part in this aircraft application illustrates one of many felt uses . . . classified authoritatively in the valuable reference work pictured below. Can felt be profitably used? What type of felt? These questions are constantly before Design, Production and Purchasing executives. The Booth chart answers them. BOOTH FELT COMPANY, 475 19th Street, Brooklyn, New York, 736 Sherman Street, Chicago, Ill.
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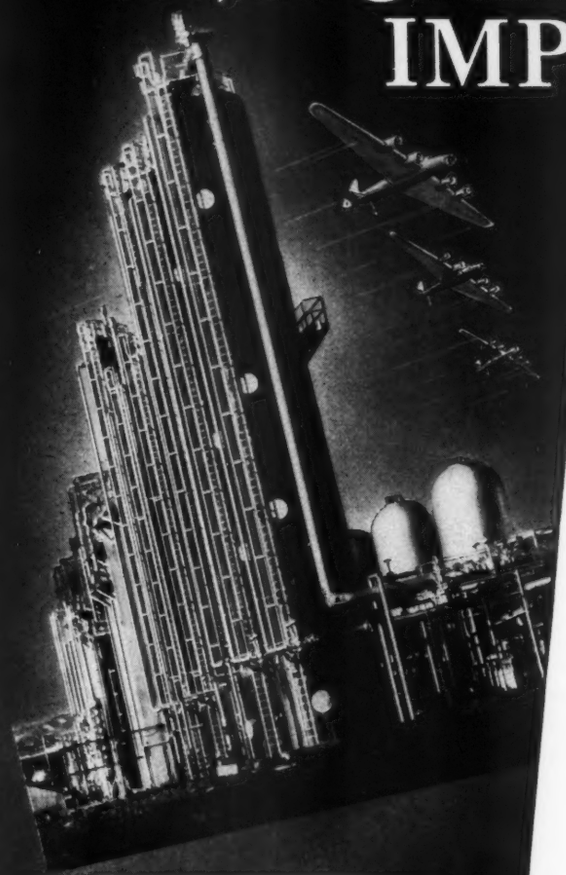

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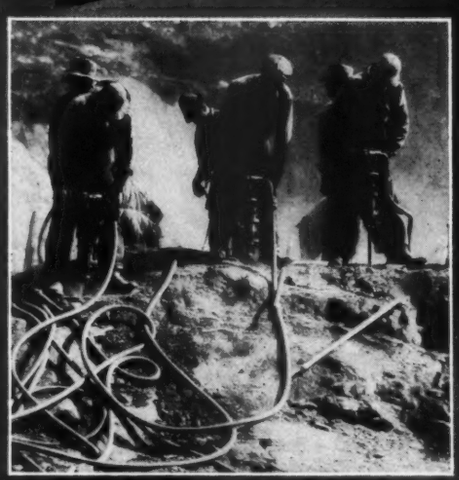

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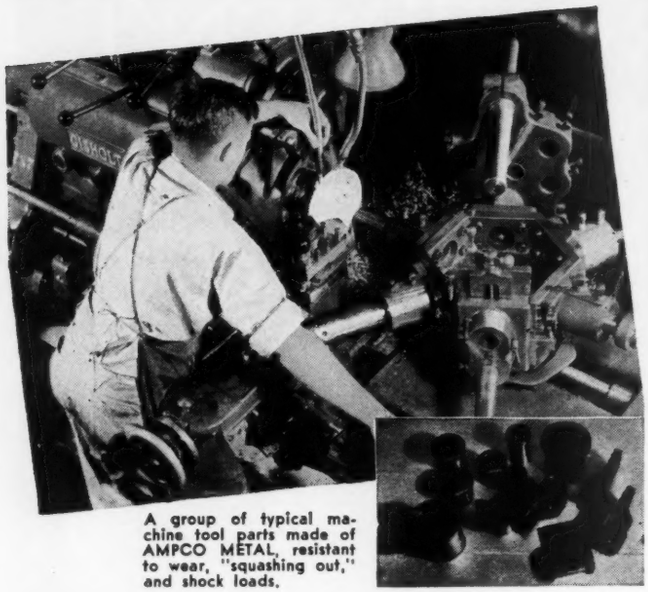

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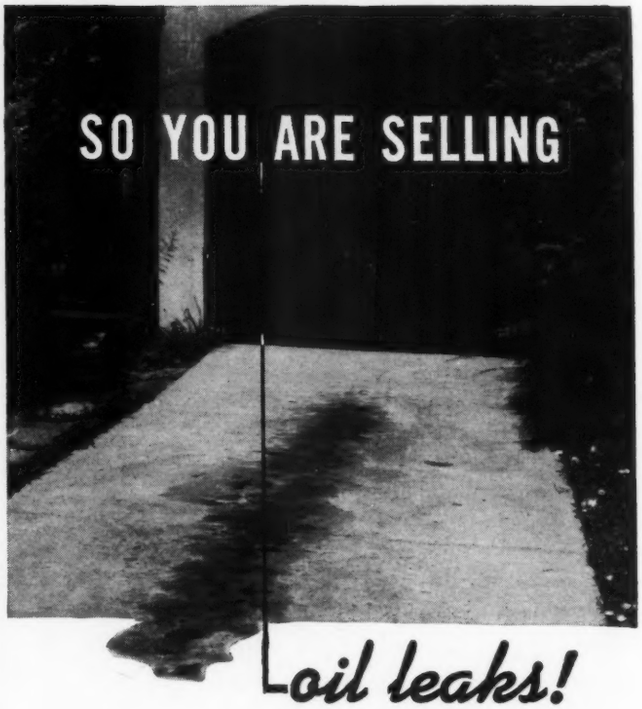

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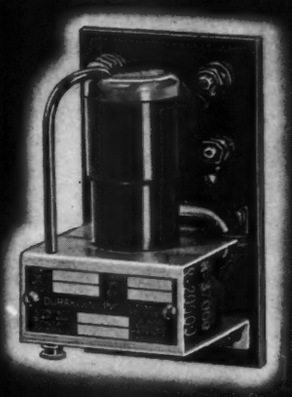

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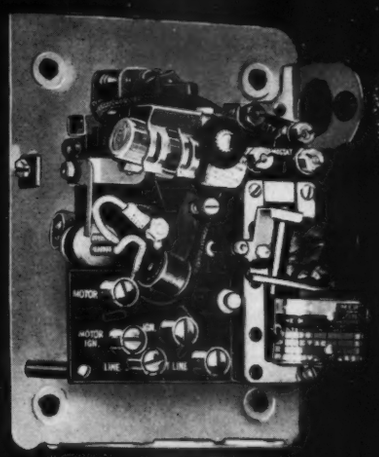

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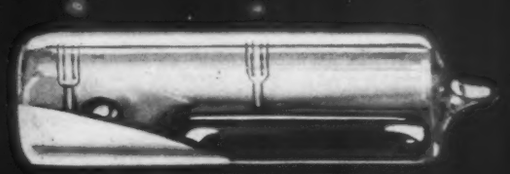

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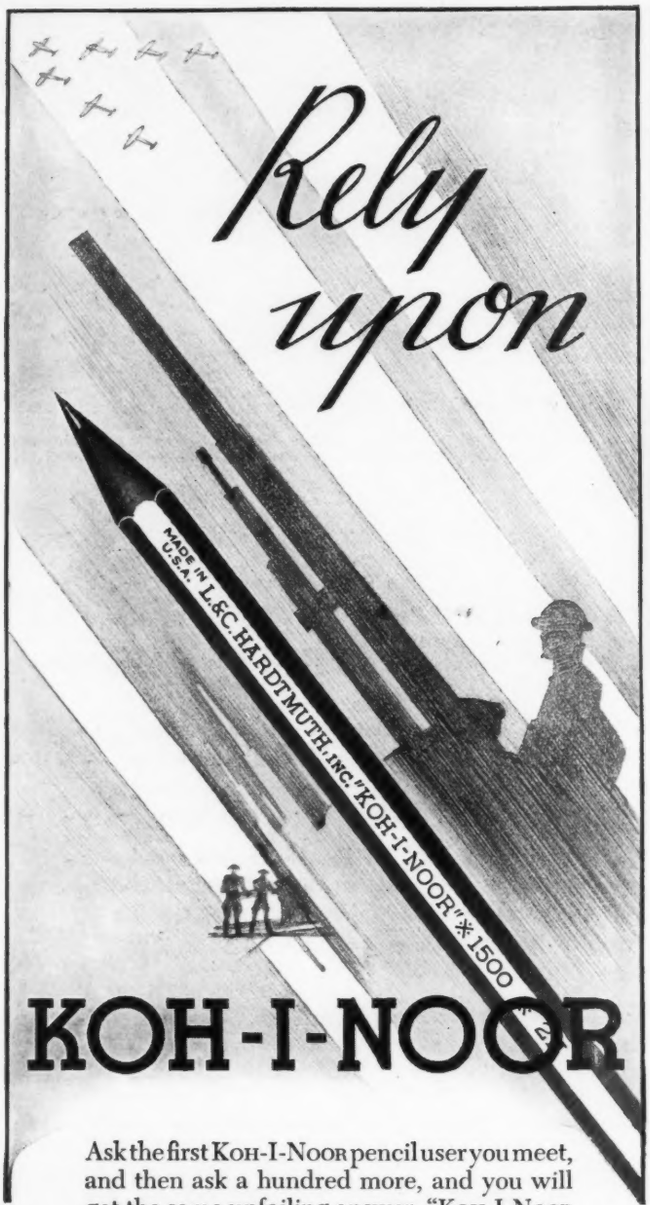

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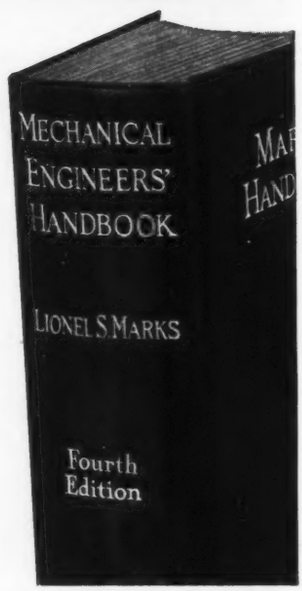

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(3) TEMPERATURE CONTROLS—The Foxboro Co. Folder, 3 pages. Temperature indicators and controllers for electroplating baths are described and illustrated in this folder. Details of standard types are given.

(4) WELDING ACCESSORIES—Weltronic Corp. Bulletin S-41. Describes a complete line of resistance welder heat-controls, synchronizers, and synchronous timers, as well as its line of power and control units for welding equipment and automatic machinery. General technical material on welding is included.

(5) MEASUREMENT ACCESSORIES—Brown Instrument Co. Catalog, 24 pages. This catalog, entitled "Thermometer and Pressure Gauge Accessories," lists and describes all accessory items for the line of thermometers and gages made by this company. It contains many photographs and tables of dimensions and sizes.

(6) LUBRICATION MANUAL—Gits Bros. Mfg. Co. Catalog, 172 pages. This large well-bound book discusses every phase of lubrication and presents a wide line of available equipment. Discussions and catalog items are profusely illustrated.

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(9) LUBRICATION SYSTEM—The Farval Corp. Bulletin, 8 pages. This booklet discusses the general problem of lubrication, and then, by means of three-color illustrations, illustrates the advantages of this system. The simplicity of the system is brought out particularly.

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(12) SPEED REDUCERS—D. O. James Co. Catalog 19, 48 pages. Filled with curves, many tables, illustrations and blueprints, this catalog on parallel-shaft, continuous-tooth herringbone speed reducers contains much information for the design engineer. Design formulas and examples of applications may be found here too.

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(14) TOOL STEEL — Jessop Steel Co. Booklet, 8 pages. This booklet describes the Jessop Lion Brand Carbon Tool Steel, and describes the various metallurgical operations it may undergo. Various uses are listed, and best methods of preparation are indicated.

(15) NYLON BRISTLES — Du Pont Co. Booklet, 16 pages. The booklet gives a short history of Nylon, outlines its advantages, reports on its uses in many industries, and lists its general physical and chemical properties. Many photographs and a sample of Nylon are included in the booklet.

(16) HIGH-TEMPERATURE STEELS— Timken Roller Bearing Co. Bulletin, 8 pages. This digest of steels for high-temperature service contains considerable data on the chemical and mechanical characteristics of these steels. Included, too, are photographs of the microstructures of many samples.

(17) TECHNICAL DIGEST — Graham Transmissions, Inc. Bulletin, 4 pages. This is a monthly digest of current technical news for industrial executives. Articles from original engineering sources are presented in abstracted form.

(18) RADIANT ENERGY — Fostoria Pressed Steel Corp. Bulletin, 16 pages. Illustrated with pictures of applications and equipment, this manual discusses infra-red radiant energy and how it works. Applications in the industrial, printing and motor-baking field are described.

(19) WRINKLE FINISHES — New Wrinkle, Inc. Bulletin, 12 pages. Describes the various uses of wrinkle finishes on many industrial products. Advantages are explained and well illustrated.

(20) ELECTRODE CONSUMPTION CALCULATOR—Air Reduction. Bulletin, 8 pages. Cost of arc welding electrodes for any type of joint on any thickness with either bare or coated electrodes may be rapidly estimated by use of this booklet. Tables and basic formulas are included.

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(28) CENTRIFUGAL CASTINGS—Ampco Metal, Inc. Bulletin, 6 pages. This illustrated bulletin contains a detailed story of the benefits to be obtained from centrifugal castings. Both technical and commercial advantages are stressed, but limitations are also explained. For the designer's convenience, there is a table of maximum casting sizes.

(29) INDUSTRIAL PUMPS — American Manganese Steel Div. Bulletin 940, 24 pages. A well-illustrated bulletin which describes in detail their full line of pumps. Dimension data, blueprints, and photographers are included with written explanations of special features. Characteristic curves of capacities are shown for all pumps.

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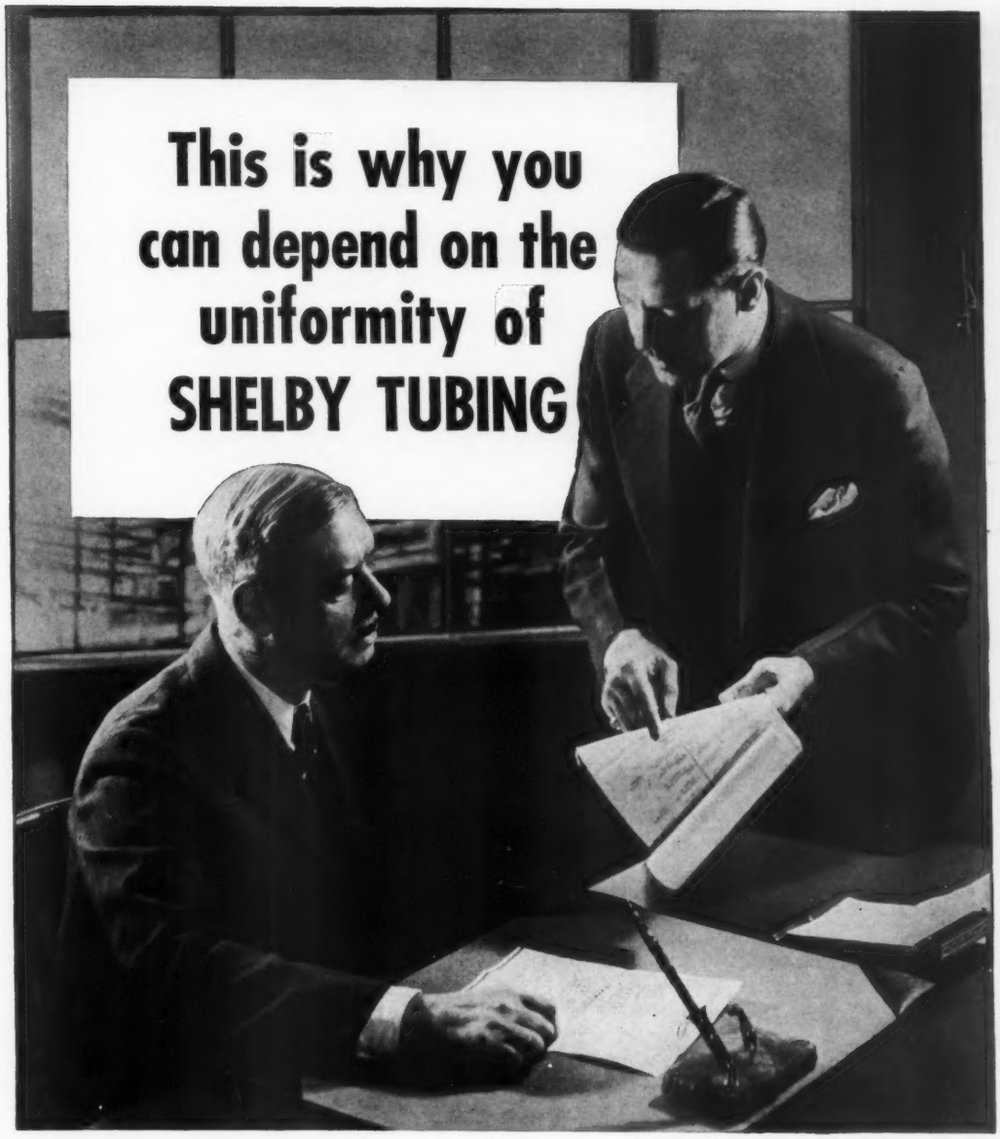

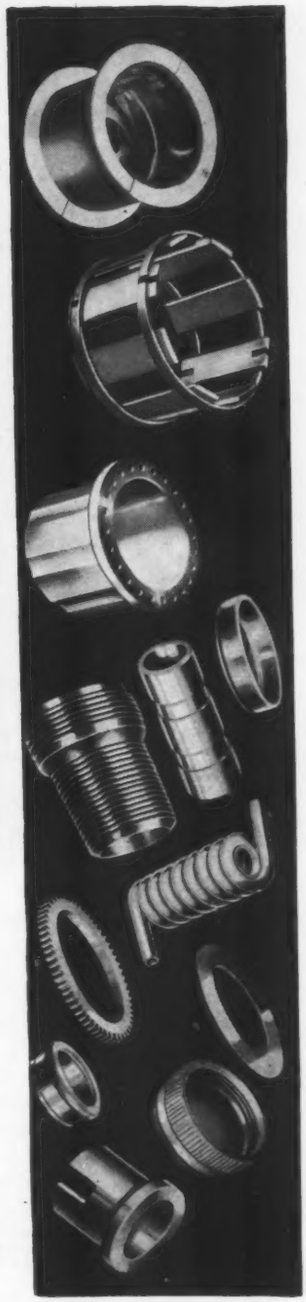

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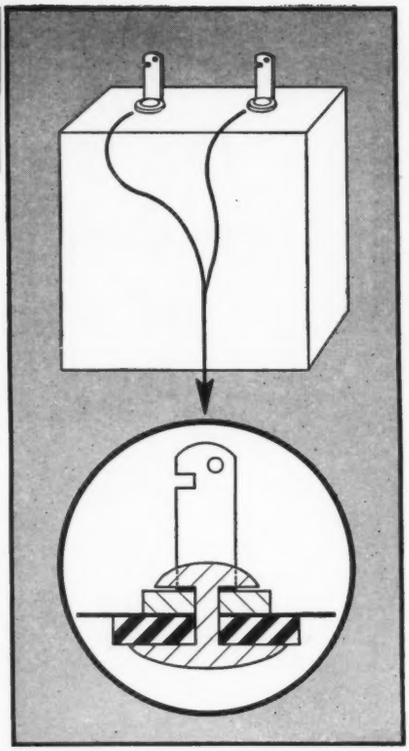

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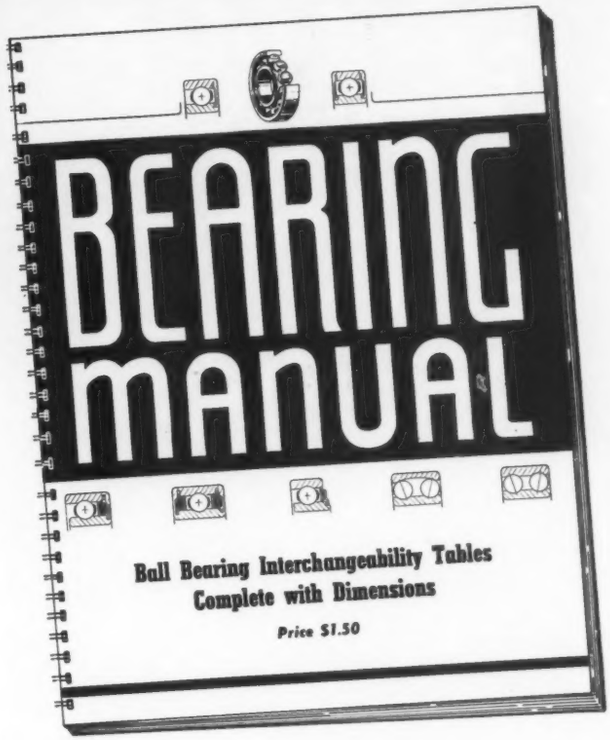

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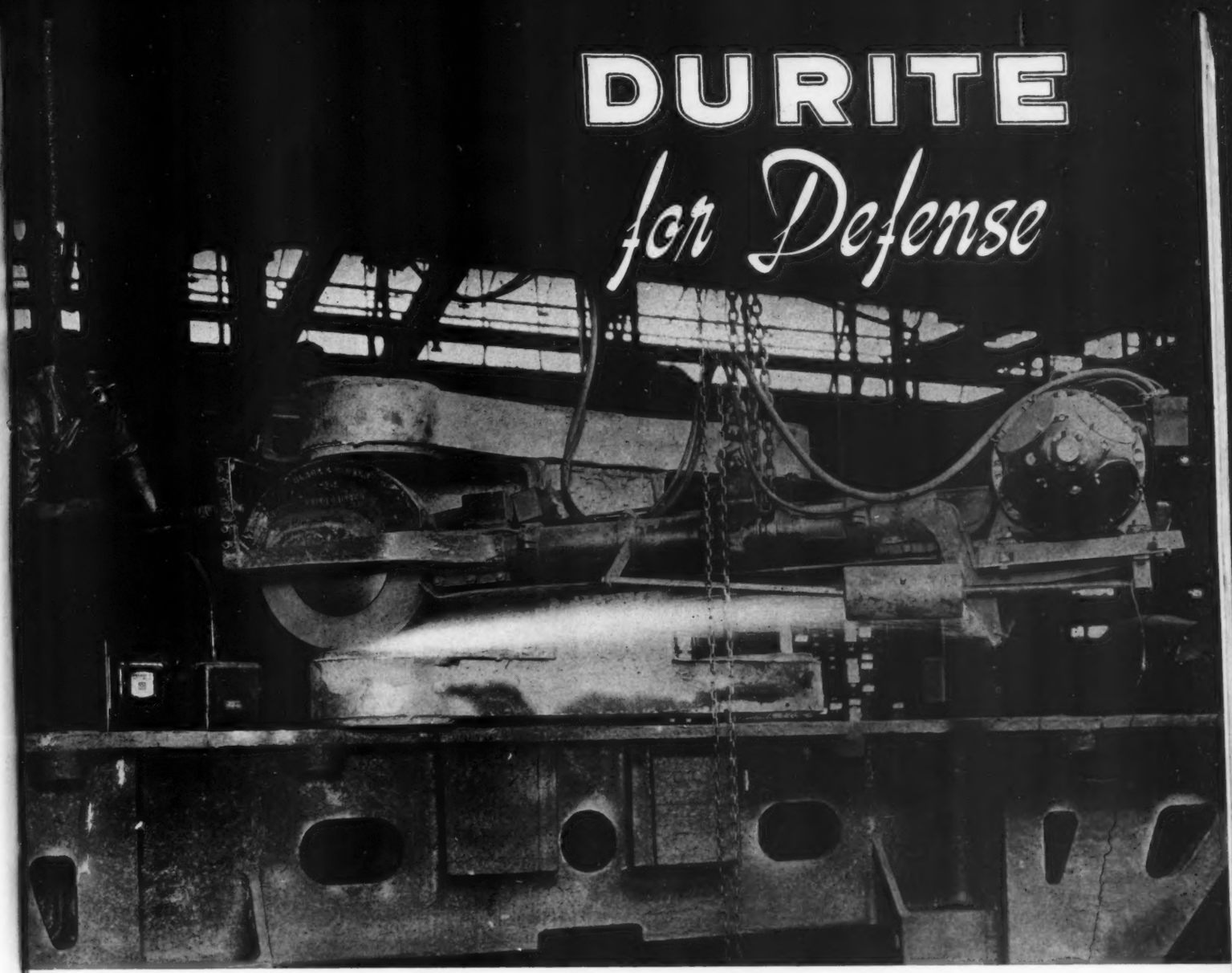

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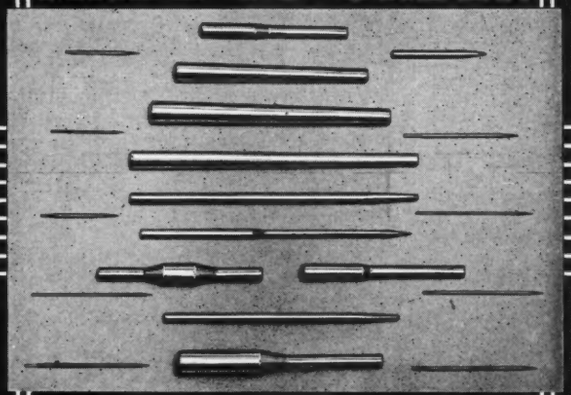

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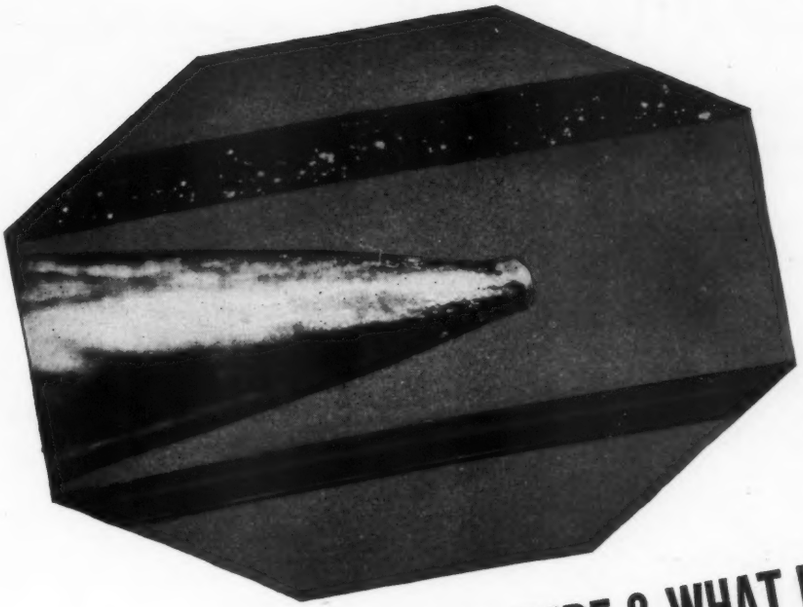

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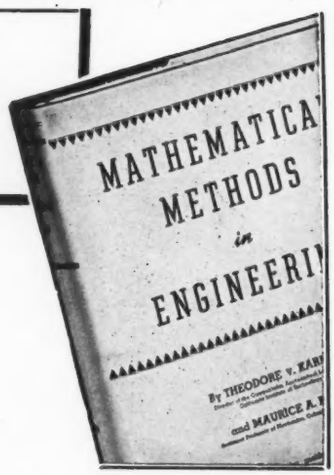

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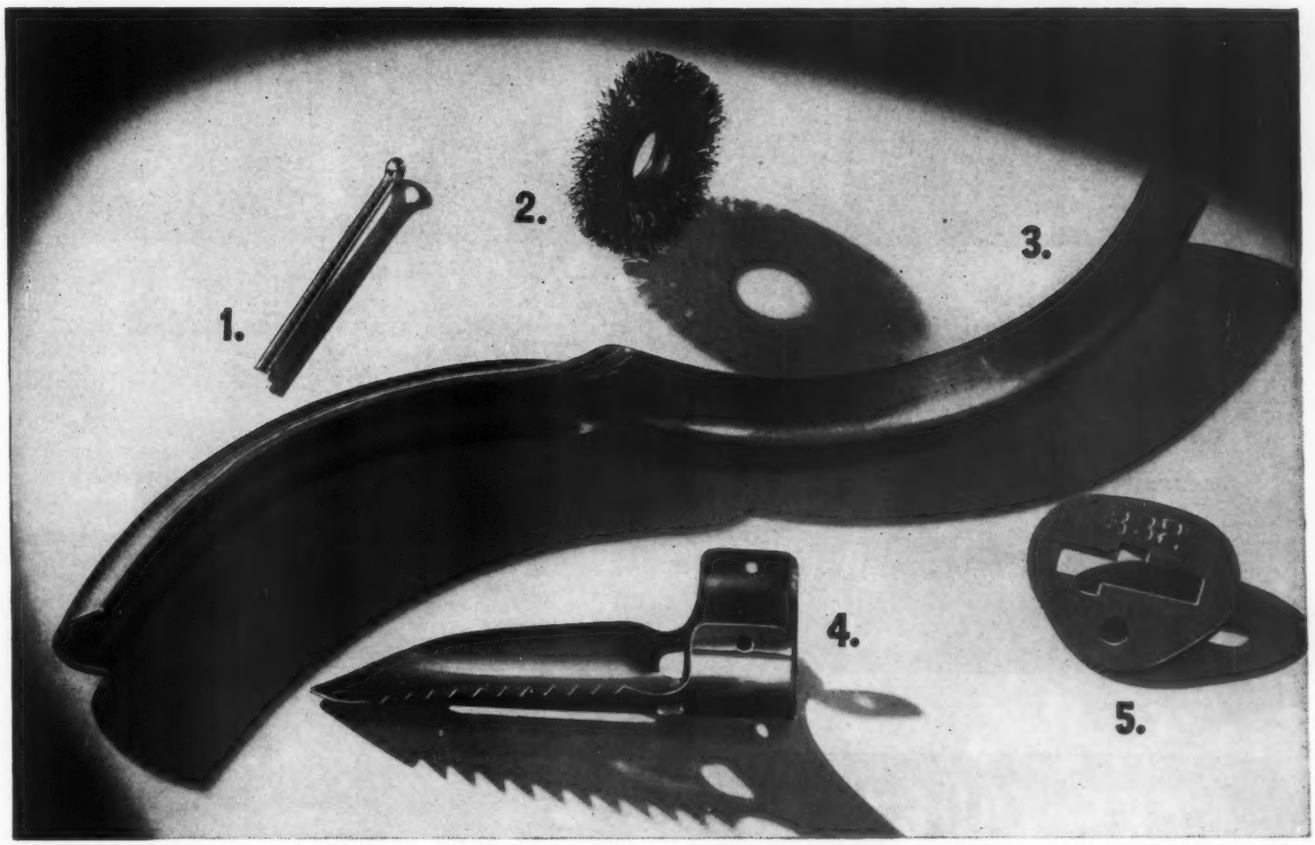

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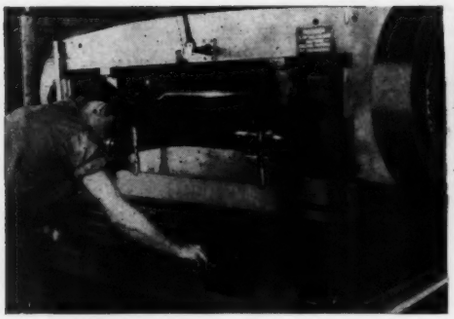

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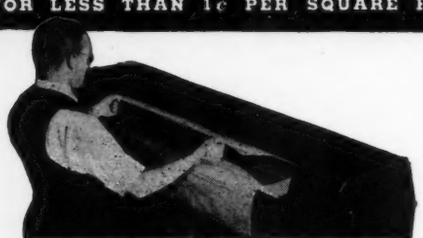

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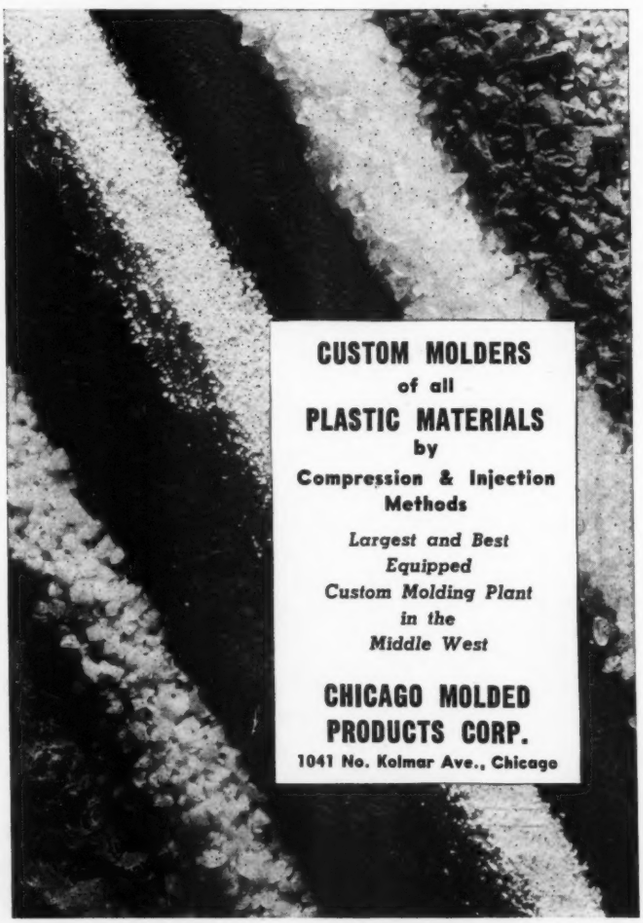

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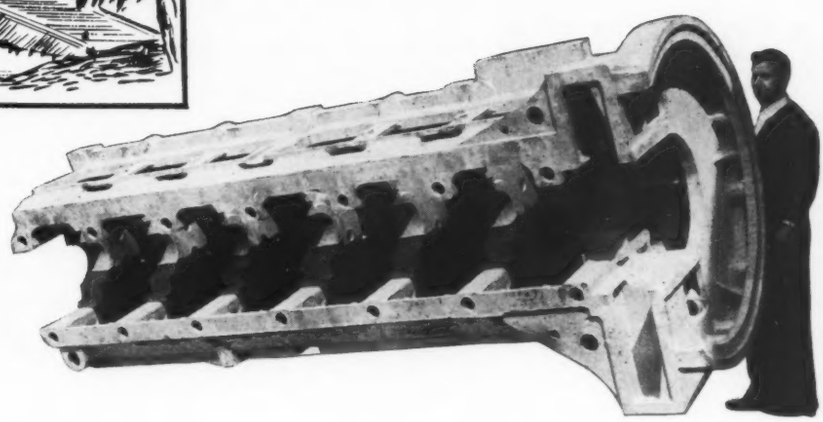

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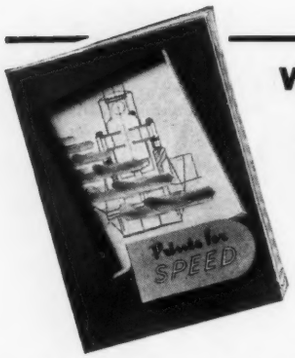

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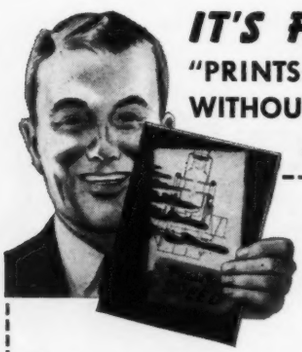

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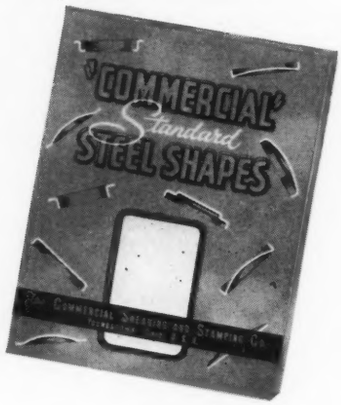

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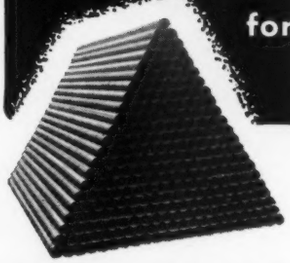

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Of Product Engineering, published monthly at Albany, N. Y., for October 1, 1941.

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SEARCHLIGHT SECTION

(Classified Advertising)

EMPLOYMENT : BUSINESS : **"OPPORTUNITIES"** : EQUIPMENT : USED OR RESALE

UNDISPLAYED —RATES— DISPLAYED

10 CENTS A WORD. MINIMUM CHARGE $2.00
Positions Wanted (full or part time salaried employment only), ½ the above rates payable in advance.
Box Numbers—Care of publication New York, Chicago or San Francisco offices count as 10 words.
Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Individual Spaces with border rules for prominent display of advertisements.

The advertising rate is $6.50 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page.

(Copy for new advertisements must be received by Dec. 17th for the Jan. issue subject to space limitations)

POSITIONS VACANT

DESIGNING ENGINEER — Barber-Greene Company, Aurora, Illinois, in expanding the Engineering Department, has opportunity for an outstanding creative designing engineer with proven ability and experience on heavy machinery. Age between 30 and 45.

MACHINE DESIGNER. Experienced designer —mechanical engineer preferred—to expand and develop improved lines of equipment of the following types—mechanical presses, plastics molding equipment, high vacuum pumps, vacuum processing apparatus, as well as certain types of automatic machinery. An excellent opportunity for an outstanding creative designing engineer, with proven ability. F. J. Stokes Machine Company, Olney Post Office, Philadelphia, Pa.

ENGINEER for electrical testing in research laboratory of an Electric Appliance Manufacturer in central states. State experience and salary expected. P-237, Product Engineering, 520 N. Michigan Ave., Chicago, Ill.

WANTED
ENGINEERS
Nationally known New Jersey manufacturer needs Mechanical and Electrical Engineers.
Diversified products offer inviting opportunities in engineering field.
MECHANICAL ENGINEERS required for development of processes and machinery for manufacturing and reducing costs of precision apparatus and to plan production methods for assembly and wiring. Also, development, layout, cost reduction work on material handling, storage and packing problems.
ELECTRICAL ENGINEERS needed for high grade work on test set design, special circuits, electronics and vacuum tube manufacture.
Must be Engineering graduates of accredited colleges, high scholastic standing. Some manufacturing experience preferred. Salary commensurate with ability and record of accomplishments.
MUST BE U. S. CITIZENS
Write, stating qualifications
Box 550, Suite 1800, Times Bldg., N.Y.

"Opportunity" Advertising:
Think
"SEARCHLIGHT"
First

POSITIONS VACANT

MECHANICAL ENGINEER WANTED. — Experienced product designer having technical training. Work will be establishing design and supervision of production engineering for mechanical parts and mountings for interesting national defense radio and electrical products. This work will develop into a line of commercial electronics products after the present emergency is over. Write giving information covering education and experience. Salary arranged. All communications will be treated confidentially. Raytheon Manufacturing Company, 190 Willow Street, Waltham, Massachusetts.

INSPECTOR with practical shop background, several years experience, 35 years old or older, qualified to assist in directing inspection work in small aircraft accessory defense manufacturing plant in Newark, N. J. P-238, Product Engineering, 330 W. 42nd St., New York, N. Y.

POSITIONS WANTED

DESIGNING ENGINEER with Inventive and Creative Ability will be available in January. Are you paying for the use of patents. Why not own your own? I can develop products with unique and advanced features to avoid competition and design testing equipment and automatic machinery. Twenty-five years experience. B.S. in Mechanical Engineering and E.E. degree. Salary $10,000 unless you prefer a royalty arrangement on new products developed. PW-233, Product Engineering, 520 N. Michigan Ave., Chicago, Ill.

TRAINED as mechanical and electrical engineer I have managed successfully large and medium sized manufacturing plants both here and abroad. My present position with large airplane company is not to my liking. I desire connection with some medium size business where I can use my energies and demonstrated abilities to better advantage. Write me and I will furnish my complete history. My record includes management, research and industrial engineering, national surveys, lectures and writing for industrial journals on technical and managerial subjects. I can locate anywhere. Prefer salary plus bonus on accomplishment. PW-236 Product Engineering, 330 W. 42nd St., New York, N. Y.

INSTRUCTION

BETTER PRODUCT DESIGNING taught in your spare time at home. Write for full details. Trofimov School of Inventive Practice, Inc., Hanna Road, Willoughby, Ohio.

WANTED

ANYTHING within reason that is wanted in the field served by Product Engineering can be quickly located through bringing it to the attention of thousands of men whose interest is assured because this is the business paper they read.

Long established manufacturer of medium and heavy precision machinery is in the market for patented or patentable ideas or inventions requiring development for production and marketing.
Want items applicable to the defense program or suitable for industrial use after the emergency. Both machinery and other products lending themselves to small volume production will be considered. Send complete details on protected ideas to —
BO-235, Product Engineering
520 No. Michigan Ave., Chicago, Ill.

What is *your* problem?
Competent men for your staff? . . . employment? . . . or are you looking for—or offering—a business opportunity of special interest to readers of this publication? You can get their attention—at small cost—through an advertisement in the Searchlight Section of Product Engineering.

SUPPORTING 20 Tons, INSULATING

Against 8 Million Volts

The complex apparatus you see above is the new electrostatic generator at the University of Notre Dame. It is an atom smasher capable of developing eight million volts. It weighs twenty tons.

Obviously, the machinery to disintegrate nuclei by high speed electrons, depends upon hundreds of contributing factors for its successful operation. Each of these is vitally important to the process.

One of the materials in the generator, which performs a double duty well, is G-E Textolite laminated tubing. As a structural material, it is used to support the entire twenty-ton machine. As an electrical insulator, it withstands eight million volts.

The new generator is the second at Notre Dame to incorporate Textolite tubing. Although an unusual application, it is indicative of the many uses to which this material is being put for both mechanical and electrical purposes.

For the properties of this material and a thorough description of G-E Plastics Department's complete service, ask for a copy of our Textolite booklet. Write Section B-125, General Electric Co., 1 Plastics Ave., Pittsfield, Mass. PD-159

PLASTICS DEPARTMENT

GENERAL ELECTRIC

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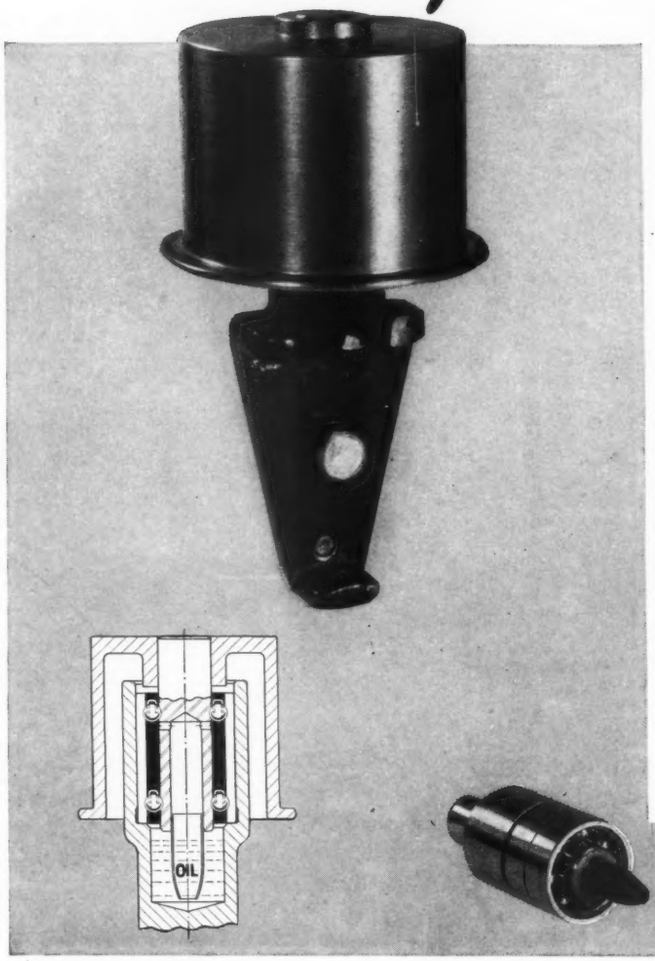
inside it's always *raining*



● Yes, a continuous shower of tiny drops of oil inside this Tension Pulley Ball Bearing keeps balls and raceways automatically lubricated. It is the *first* anti-friction bearing with its own oil-circulating system—a permanent built-in feature, enabling it to run for a year or more without attention.

Since the products of New Departure are *ideas* as well as ball bearings, this company has developed many "famous firsts," has revolutionized mechanical design in many industries.

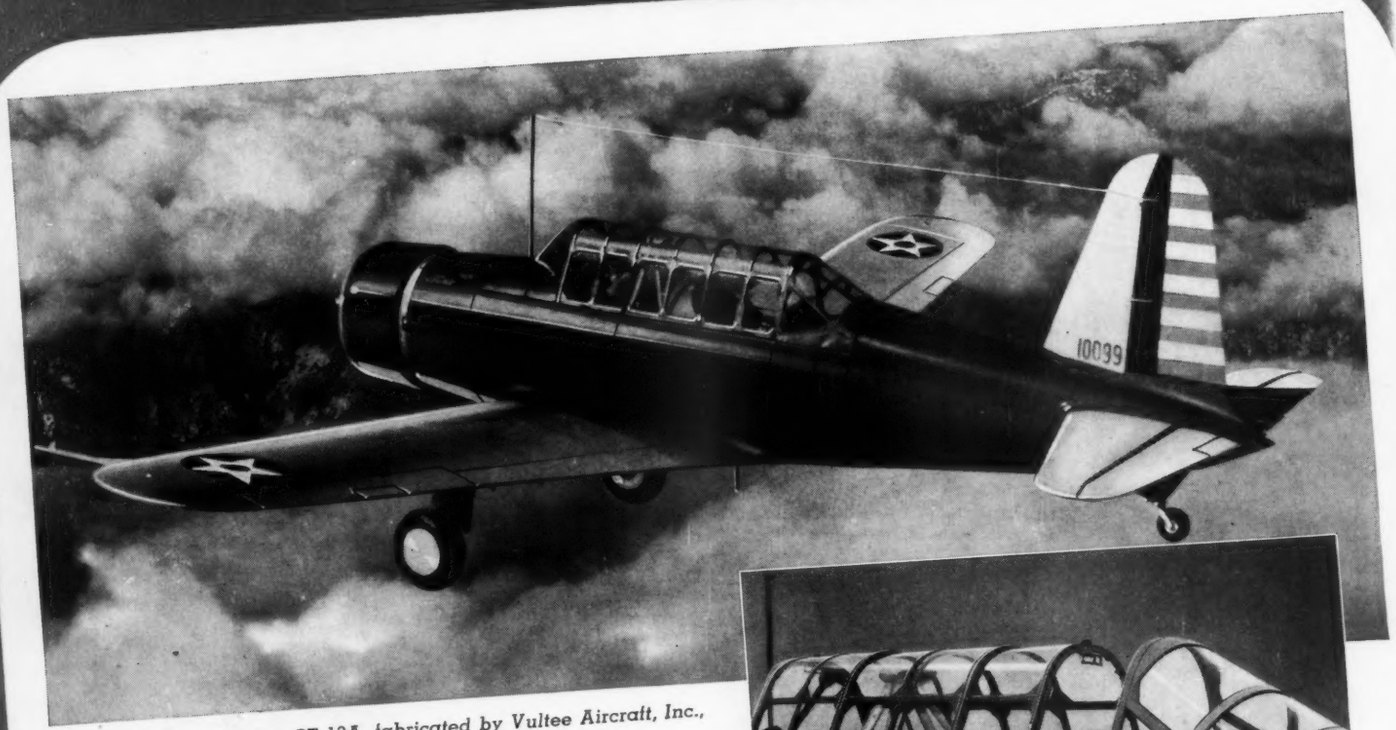
Nothing rolls like a ball. Ball bearings are used wherever shafts turn. Ask for your copy of that absorbing, superbly illustrated treatise: "Why Anti-Friction Bearings." New Departure, a division of General Motors, Bristol, Connecticut. Chicago and Detroit.

New Departure

. . THE FORGED STEEL BEARING

December, 1941

DOWMETAL MAGNESIUM

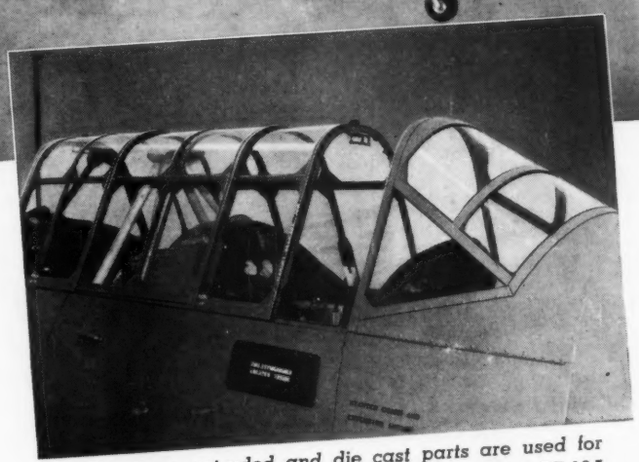


Vultee Basic Trainer, BT-13A, fabricated by Vultee Aircraft, Inc., Vultee Field Division, Vultee Field, California

VULTEE CANOPY FRAMES OF EXTRUDED PARTS

The use of magnesium alloys in the extruded form is progressing rapidly. In airplane construction, for example, such parts include extruded sections of DOWMETAL* for seats, panel stiffeners, fillers, various cabin parts and for canopy framing, such as the cockpit canopy for the Vultee Basic Trainer BT-13A, shown above.

DOWMETAL, unique as a weight-saving metal, is readily fabricated by all the usual methods. Technical data is available. Dow invites consultations.



DOWMETAL extruded and die cast parts are used for the cockpit canopy of the Vultee Basic Trainer BT-13A

A CITATION OF USEFULNESS

It is gratifying to Dow that magnesium is playing such a vital role in the furtherance of our security program. Millions of pounds of this metal, produced by Dow, are now going into aircraft and other defense equipment. Placement on the priority list is, truly, a citation of distinction—evidence of indispensable usefulness which industry understands and appreciates.

THE DOW CHEMICAL COMPANY
MIDLAND MICHIGAN

New York City, St. Louis, Chicago, San Francisco,
Los Angeles, Seattle, Houston

*Trade Mark Reg. U.S. Pat. Off.

TRADE MARK DOWMETAL MAGNESIUM ALLOYS

CASTINGS • FORGINGS • SHEET • STRIP • PLATE • EXTRUSIONS

LIGHTEST OF ALL STRUCTURAL METALS

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